

Chemical Engineering Progress

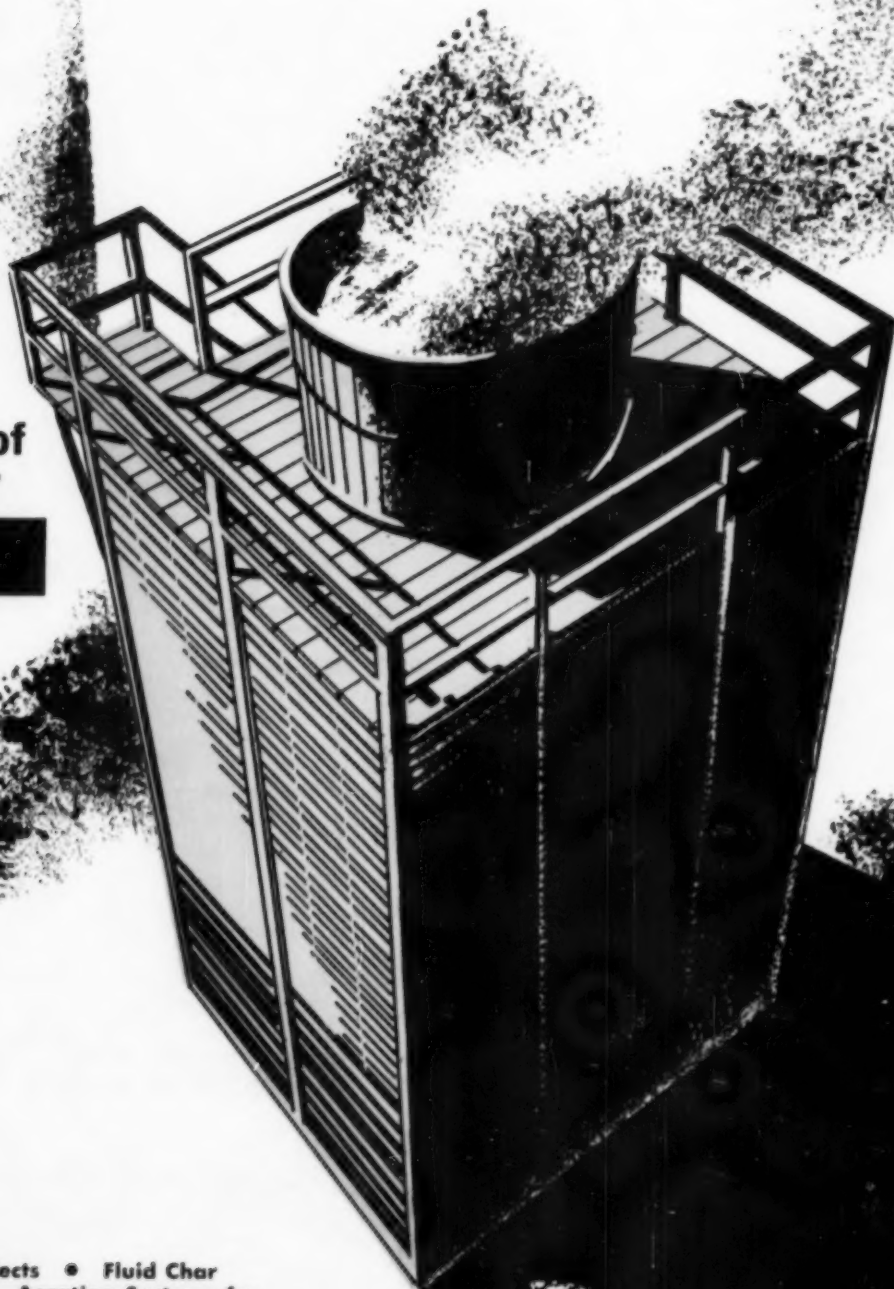
JULY 1956

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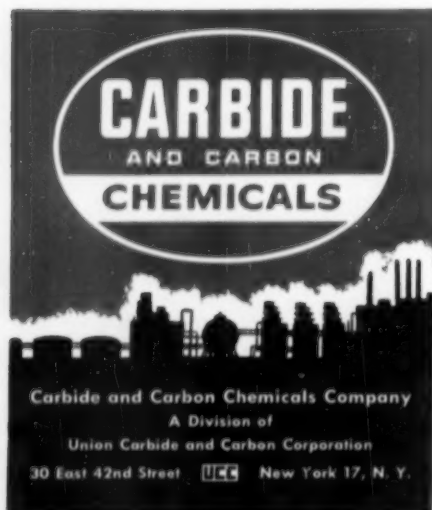
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what's in this issue

July, 1956 • Volume 52, No. 7

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for sizing dry chemicals
it's the **BAR-NUN** Sifter



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Multiplies screening capacity in same floor space

In some plants, installation of a modern Bar-Nun Rotary Sifter has doubled or tripled screening capacity in the same floor space. The Bar-Nun provides up to 40 square feet of screen surface in a floor area only $3\frac{1}{2}$ feet square . . . up to 70 square feet in slightly larger floor space!

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Many processes now require uniformly sized particles—for product quality control, or for efficient operation of production equipment. If this is true in your plant, a Bar-Nun Rotary Sifter will prove the lowest cost sifter over a period of years.

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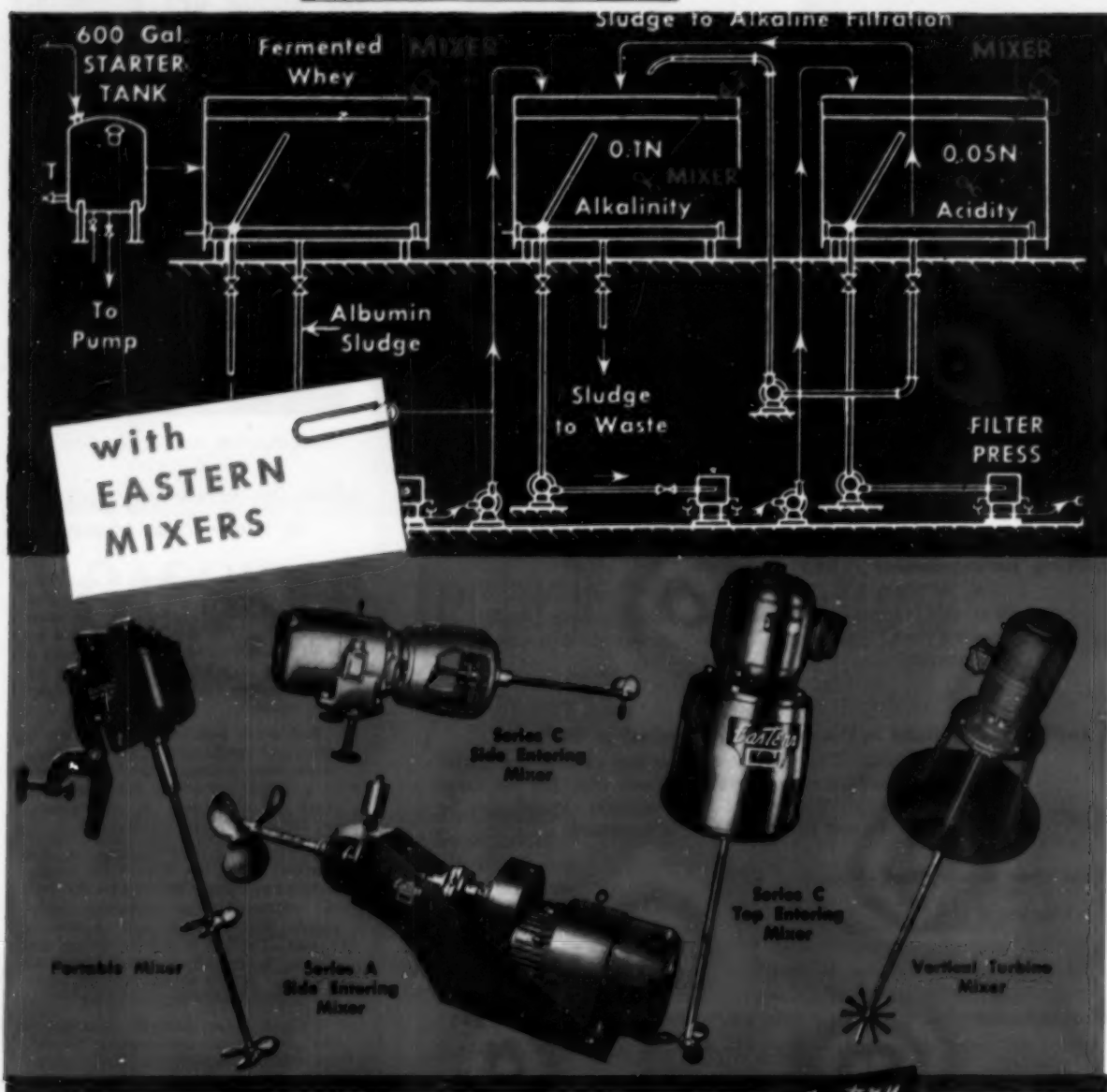


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what's in this issue

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relations useful in aeration systems for treatment of biological wastes. Oxygen transfer vs. utilization is first analyzed, then performance qualities of the various components of equipment are discussed.

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Experiences with mixed-bed deionization / 299

G. P. Monet—How to avoid or overcome difficulties in the design and operation of mixed-bed deionizers, is the subject of this paper, which is based on the author's experience with commercial sized units producing waters of 5×10^6 ohm-cm. average specific resistance, at a cost of 1/3 to 1/5 that of distilled water.

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A.S.E.E. committee report says "yes" but problems remain in "how" to provide, "how not" to displace important technologic subjects.

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Midland brings the university to the engineer / 98

E. R. Cowherd—A dynamic program of bringing university training to chemical engineers located in an industrial center about 100 miles distant from campus.



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Letters to the editor

Just a Suggestion

May I suggest the addition of a "re-cycle line" in the flowsheet shown in "Cost Estimating and Decision Making," (Hicks & Steffens, May, 1956, page 191.)?

The "Result" of one "Decision" immediately becomes the "Data" of the next "Decision." Also, a decay rate or half-life should be considered for the data.

R. J. Hennig

Detroit, Michigan

To Donald S. Ullock

I read with great interest your article published in *Chemical Engineering Progress* entitled, "Evaluating the Mechanical Design of End-Suction Centrifugal Pumps," [C.E.P., 31, No. 5, 207 (1955)] which was sent to me by Mr. Thomas of Economy Pumps Inc.

We make a very extensive range of pumps which are used in various industries, including the chemical industry, and we think that the work which you have done is of great value to designers and users.

M. Sigmund

Team Valley, Gateshead II
England

Noted and quoted

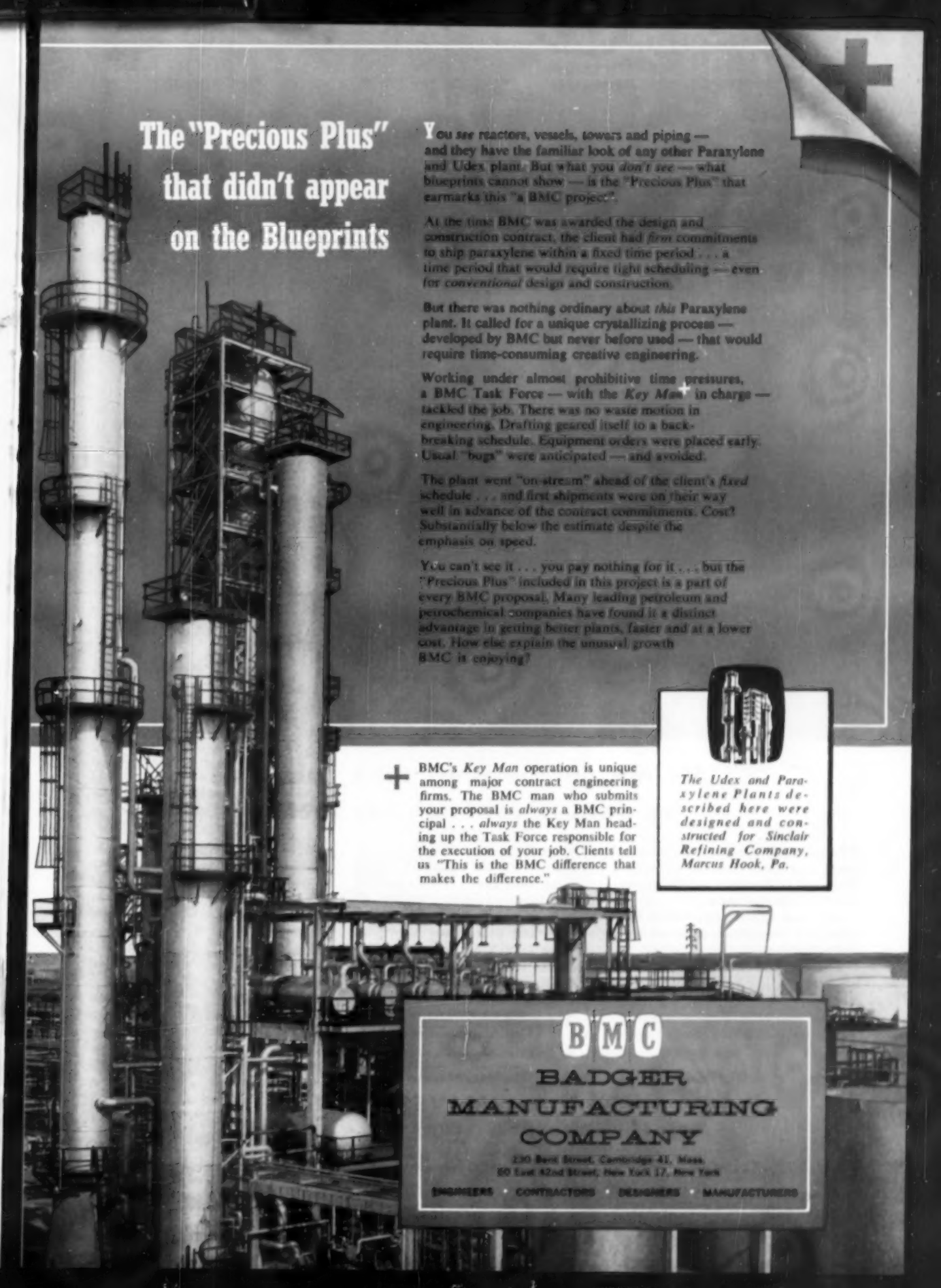
Research and the Engineer

The intelligent application of science requires training in the techniques of research. At the graduate level, research and instruction go hand in hand, but what about the undergraduate? What does research do for him? Formal research in an educational institution does a number of things for the undergraduate student even though he does not participate in it directly. . . .

Above and beyond these direct benefits, however, is a broader and more important concept. Research is the indispensable attribute of the engineer who will advance his profession or even keep up with it. In this sense all engineers must conduct research if they are to realize the potentialities of their chosen profession or to make their dreams come true.

Finally, and not least, is the concept of research as a way of life, an attitude of mind, a fulfillment of the human

(Continued on page 10)



The "Precious Plus" that didn't appear on the Blueprints

You see reactors, vessels, towers and piping — and they have the familiar look of any other Paraxylene and Udex plant. But what you don't see — what blueprints cannot show — is the "Precious Plus" that earmarks this "a BMC project".

At the time BMC was awarded the design and construction contract, the client had firm commitments to ship paraxylene within a fixed time period . . . a time period that would require tight scheduling — even for conventional design and construction.

But there was nothing ordinary about this Paraxylene plant. It called for a unique crystallizing process — developed by BMC but never before used — that would require time-consuming creative engineering.

Working under almost prohibitive time pressures, a BMC Task Force — with the *Key Man* in charge — tackled the job. There was no waste motion in engineering. Drafting geared itself to a back-breaking schedule. Equipment orders were placed early. Usual "bugs" were anticipated — and avoided.

The plant went "on-stream" ahead of the client's fixed schedule . . . and first shipments were on their way well in advance of the contract commitments. Cost? Substantially below the estimate despite the emphasis on speed.

You can't see it . . . you pay nothing for it . . . but the "Precious Plus" included in this project is a part of every BMC proposal. Many leading petroleum and petrochemical companies have found it a distinct advantage in getting better plants, faster and at a lower cost. How else explain the unusual growth BMC is enjoying?

+ BMC's *Key Man* operation is unique among major contract engineering firms. The BMC man who submits your proposal is *always* a BMC principal . . . *always* the Key Man heading up the Task Force responsible for the execution of your job. Clients tell us "This is the BMC difference that makes the difference."



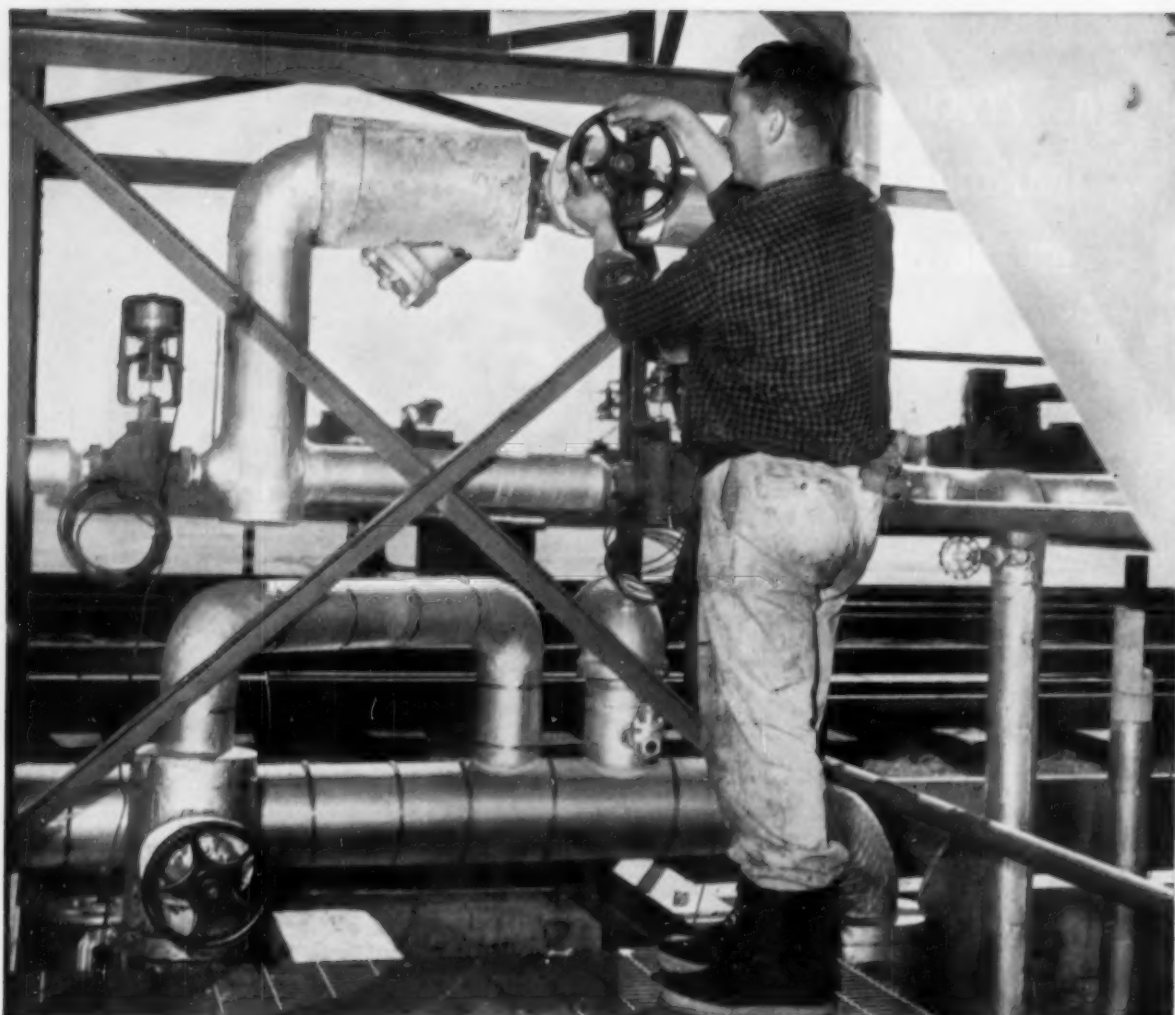
The Udex and Paraxylene Plants described here were designed and constructed for Sinclair Refining Company, Marcus Hook, Pa.

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New Crane alloy valves are helping all types of process industries

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NEWS

Heat exchanger handling strong nitric acid utilizes property advantages of Du Pont TEFLON®



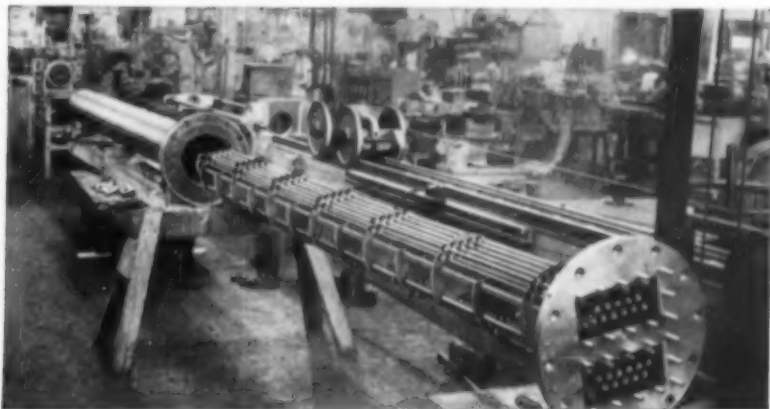
Tanks made of ALATHON® are portable and chemical-resistant

This 40-gallon-capacity tank developed by the American Agile Corporation, Cleveland, Ohio, is made of ALATHON polyethylene resin. The steel band and handles, which are used to carry the tank, were sandblasted and sprayed with a 1/16" coating of ALATHON to make the entire unit corrosion-resistant.

ALATHON has unusual resistance to chemical reagents. It is substantially unaffected by concentrated hydrochloric or hydrofluoric acids at room temperature. While permeable to certain organic acids and to some solvents and essential oils, it is not altered chemically or mechanically by these materials. The chemical and physical properties of ALATHON remain unchanged with age, assuring long, trouble-free service. ALATHON is light in weight, yet strong and flexible, can be readily heat-welded and is available in the form of film, sheet, tubing, pipe or molded products. For the complete facts on ALATHON, mail coupon.

NEED MORE INFORMATION?

Clip the coupon for additional data on the properties and applications of these DuPont engineering materials.



This heat exchanger, manufactured by Fansteel Metallurgical Corporation, North Chicago, Illinois, raises the temperature of strong nitric acid (42-50%) to 350°-375°F. One of the few metallic materials able to stand this strong oxidizing agent is tantalum; one of the few non-metallics is TEFLON.



A blade of TEFLON driven by a steel shaft covered with TEFLON is used in this new agitator designed by John L. Dore Co., Houston, Texas, for stirring corrosive mixtures under pressure. TEFLON replaced conventional glass-covered agitator, because it eliminated the problem of chipping and breaking.

TEFLON tetrafluoroethylene resin was chosen for two critical uses in this U-tube-type heat exchanger: for the grommets, inserted in the steel baffles to support the tantalum tubes, and in the form of rectangular gaskets at the header, or tube sheet.

In the grommet application, TEFLON not only supports the tubes but insulates them electrically from the steel baffle, preventing galvanic action which might damage the tantalum. TEFLON withstands the temperature of 150 to 190 psig steam, and its low coefficient of friction allows free movement of the tubes with expansion and contraction.

The gaskets of TEFLON must serve as insulation, as well as provide an acid-tight seal. The fact that TEFLON is not subject to damage from thermal shock is also important in this application.

To receive complete property data on DuPont TEFLON tetrafluoroethylene resin, clip and mail coupon.

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In Canada: DuPont Company of Canada Limited, P.O. Box 600, Montreal, Quebec

Please send me complete property and application data on DuPont TEFLON ☐ and ALATHON ☐.

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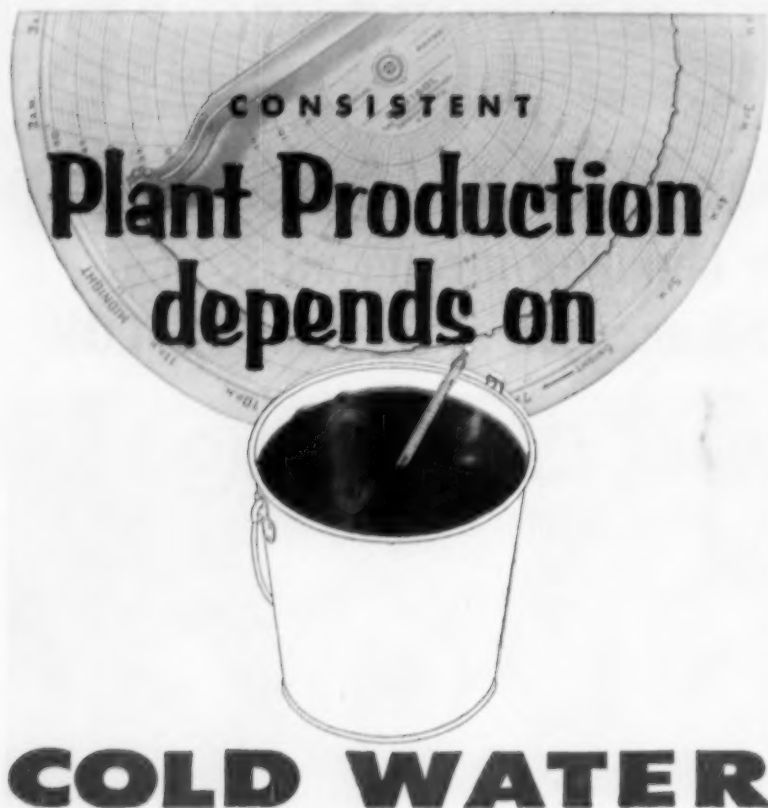
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Continuance of top-level tower performance is a single responsibility, for Marley designs and manufactures every component of its towers. It's a responsibility that Marley completely and gladly accepts. To translate this policy into action and to assure long-continued performance at specified temperature level, qualified Marley Field Service Engineers observe and check large industrial towers at frequent intervals. Their training and practical experience in tower operation and maintenance assists owners and operators to maintain the consistent cooling service that means plus production and increased operating profit.



Founder Member Cooling Tower Institute

The Marley Company

Kansas City, Missouri

Noted and quoted

(Continued from page 6)

wills to know and to tell, the preservation, the extension, and the transmission of our cultural heritage. This is the way in which the university can fulfill its obligation to society.

G. H. Hickox

"Value of Research to the Institution"
Journal of Engineering Education

Contours of Science

If there were nothing to engineering but logarithms, surveying and drafting, formulas, textbooks, field and office experience, standard practice, line and grade, cut and fill, stresses and strains, copying of precedents, pure and applied scientific research and unadorned, styleless writing, you would all be on your way to fame and fortune, and those who made the best grades in school would continue to shine and win the top prizes in later life.

Unfortunately—or perhaps fortunately for posterity—this is not the case. The elements which make for accomplishment in your profession and for advancement and success, material or otherwise, are to be found largely in qualities and talents which cannot be taught in the best of schools, and in factors which develop later and often in the most unexpected and astonishing ways.

Many great inventions have been stumbled on by searchers looking for something else. Intuitions as much as brains have lighted the path to the nuclear world. The prospector is still as potent as the geologist in the discovery of oil and minerals. . . . The successful engineer must be more than a faithful bookkeeper. In his devotion to absolute exactness and certainty he should recall that algebra was the gift of Eastern mystics addicted to symbols, that quaternions are known as the poetry of mathematics and that the basic formula governing time and space rests on relativity. . . .

Engineering is as wide as the world and as thin as its surface. Depth is something which must be acquired, can't be taught. Curiosity, observation and habit of study and reflection are the only means to reach it. The engineer abroad and in the field is at best the modern conquistador, blazing and smoothing the way for others. . . .

Robert Moses

Commencement Address
Brooklyn Polytechnic Institute

(More Noted and Quoted on page 20)

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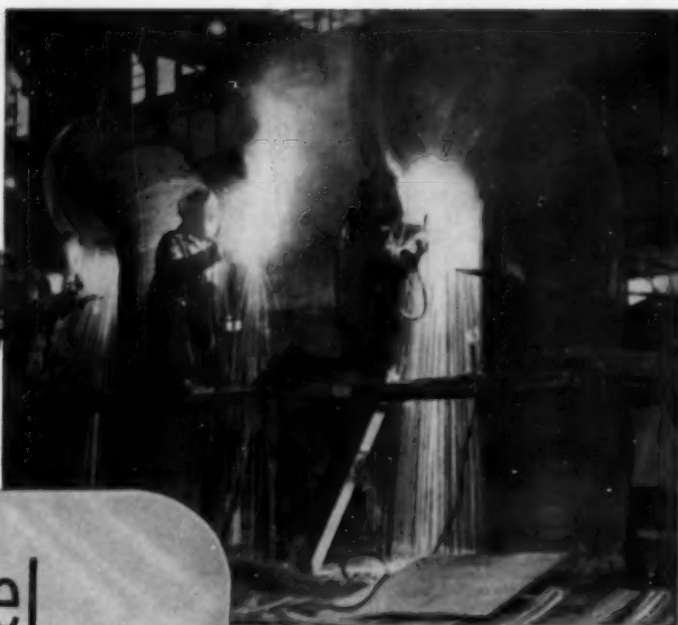
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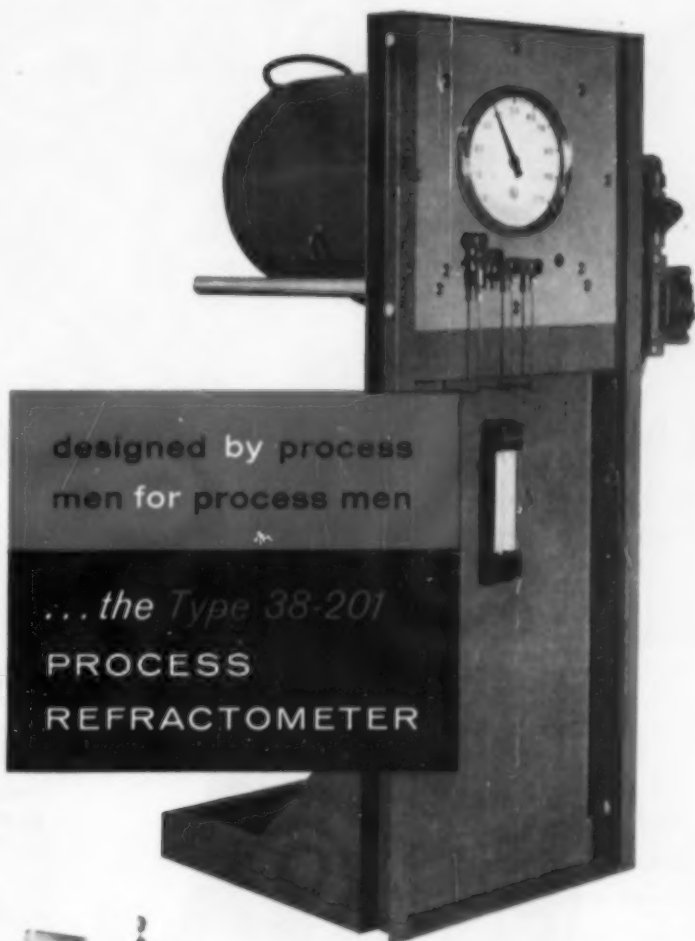
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PROCESS-CONTROLLERS...**

In addition to the Process Refractometer, CEC offers the 38-301 Oxygen Analyzer for monitoring and controlling oxygen content in gaseous streams and the 38-401 Ultraviolet Analyzer for checking purity and recovery of aromatic and diolefin streams.

**Consolidated Electrodynamics
CORPORATION**

formerly Consolidated Engineering Corporation

ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL

300 North Sierra Madre Villa, Pasadena, California

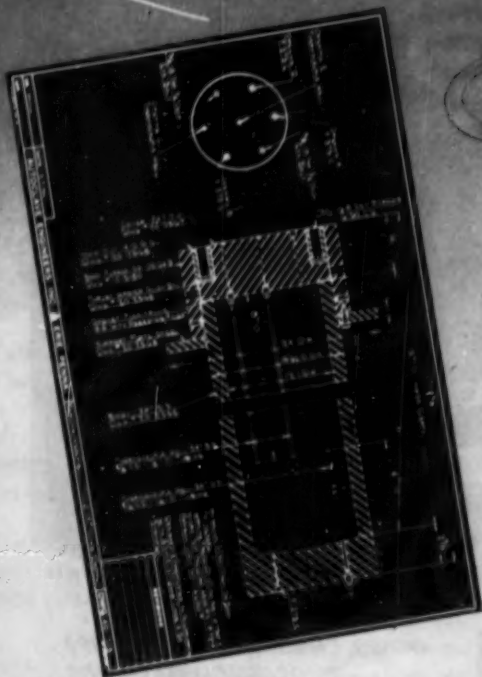
SALES AND SERVICE OFFICES IN:

Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

NOW... AUTOCLAVE builds PLANT SIZE REACTORS With Lab-Equipment Precision

Confined Basket Closures:

- Easier to Open and Close
- Occupy Less Space
- Weigh Less
- Cost Less



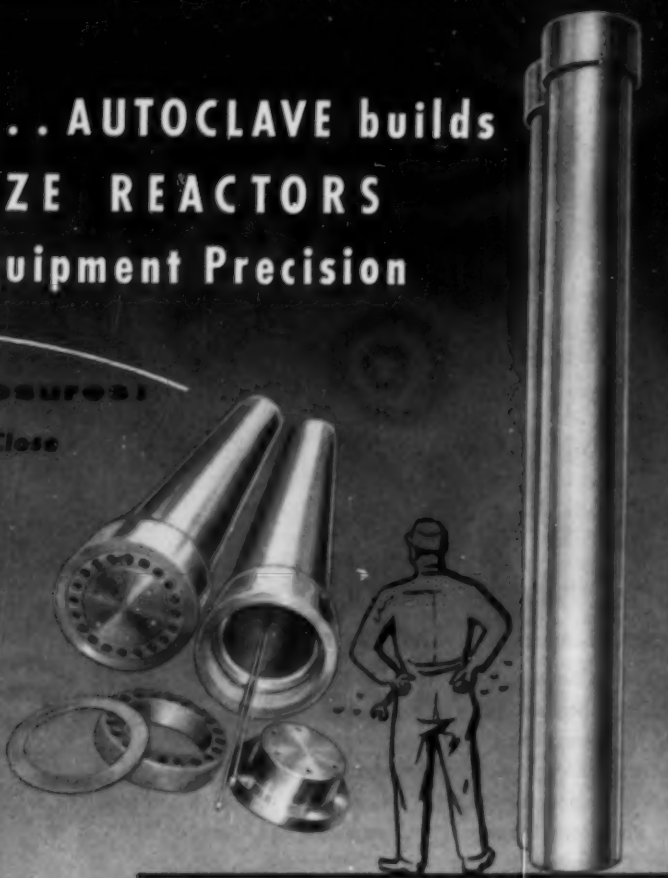
"Our products are designed and built to comply with the requirements of the ASME Code and we are authorized to apply the appropriate Code symbols."






SPECIALISTS IN
LABORATORY AND PILOT PLANT



HIGH PRESSURE EQUIPMENT

AUTOCLAVE ENGINEERS
2930 WEST 22ND STREET • ERIE, PENNSYLVANIA

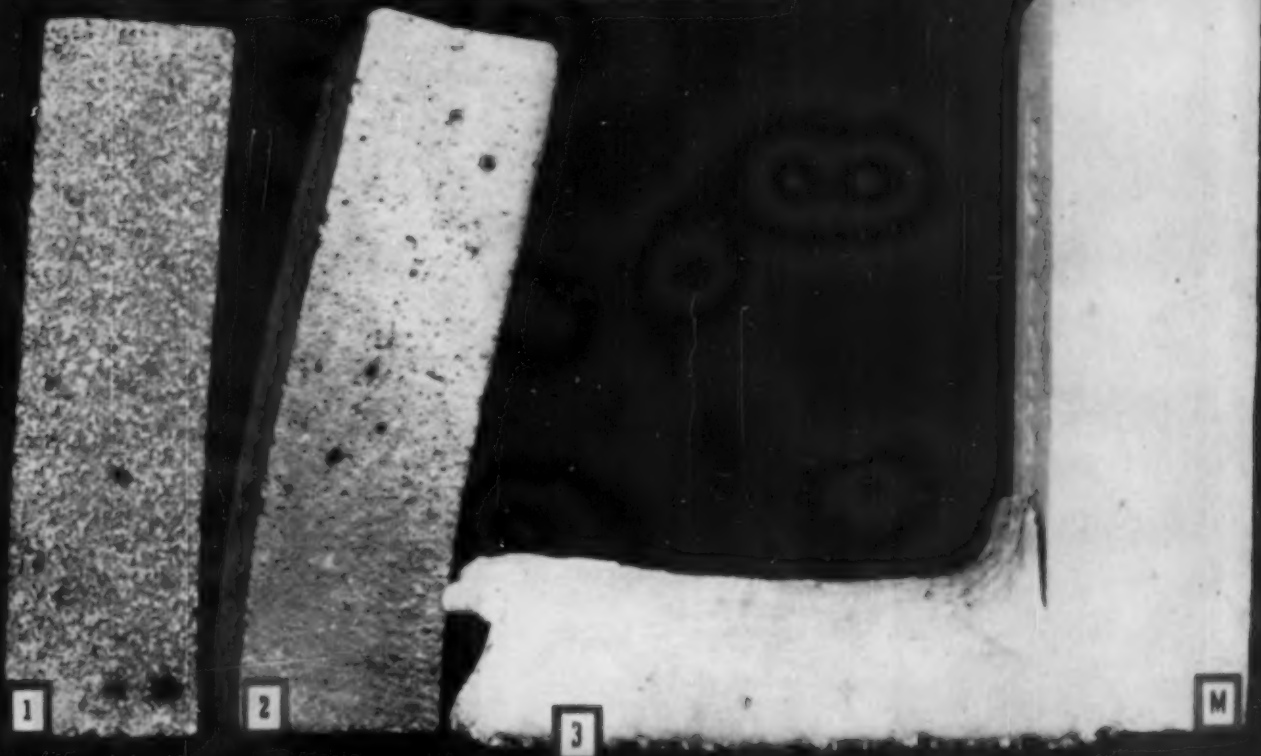


Now  offers you Plant-Size Reactors with the same performance-proven engineering and craftsmanship that characterize  High Pressure Lab and Pilot Plant Equipment. Combining the most advanced design engineering in the high pressure field with the finest materials available,  Plant-Size Reactors already have given superior performance in many atomic energy projects. Your requirements can be met by either standard  or specially-designed reactors. Take advantage of the up-to-date thinking and experience of  specialists in the design and manufacture of Plant-Size Reactors.

Send for Bulletin 356

Held at 3000°F for five hours, these four brick, commonly recommended to resist high temperatures, show varying effects. Samples 1, 2, and 3 softened and slumped to different degrees, indicating loss of usefulness even below this temperature. Sample 4, a Mullfrax® electric furnace mullite refractory, is unaffected by the heat.

fourth in a series . . . **HEAT RESISTANCE**



Unusual Properties of Refractory Materials

Heat Resistance—Exposed only to heat, Carborundum's Super Refractories can actually be used with complete safety at temperatures above 3000°F. Long before such temperatures are approached, even high heat duty and super-duty firebrick lose much of their usefulness. That's because they begin to soften several hundred degrees below their theoretical safe limits. Not so Carborundum's Super Refractories. Their strength and rigidity are maintained close to their theoretical limits.

In practice, of course, you must contend with many more conditions than heat alone. Corrosion, thermal shock, load, abrasion, erosion, etc., are usually combined with temperature. This combination of conditions may tend to lower heat resistance of refractories. That's why a refractory cannot be selected solely on its ability to withstand temperature. It also explains the reason Carborundum offers so many specialized refractories.

Heat resistance is thoroughly explored in the forthcoming issue of Carborundum's new magazine "Refractories." Send for your copy today.

CARBORUNDUM

Registered Trade Mark

VALUABLE INFORMATION FOR USERS OF:

REFRACTERIES • CASTABLE CEMENTS • POROUS PLATES AND TUBES

CATALYST SUPPORTS • OXIDE, BORIDE, NITRIDE AND CARBIDE

HIGH-TEMPERATURE MATERIALS • CERAMIC FIBER

all in the new magazine "Refractories"

-----MAIL THIS COUPON TODAY-----

Dept. G76, Refractories Division

The Carborundum Company, Perth Amboy, N. J.

Please send me the forthcoming issue of "Refractories."

Name _____ Title _____

Company _____

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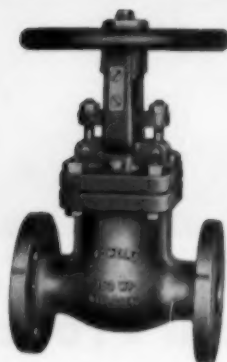
Powell packless valves for hazardous services



BELL-O-SEAL "Y" Valve with welding ends, welded bonnet and outside screw rising stem. Yoke bushing can be removed without breaking body-bonnet joint.



BELL-O-SEAL "Y" Valve (Sectional). Outside screw rising stem. Designed for long life where pressure or vacuum-tight control is essential.



BELL-O-SEAL O.S. & Y. Globe Valve. Bolted bonnet. Outside screw stem rises through upper yoke bushing that revolves with handwheel.

Painstaking quality control is rigidly enforced through every step in the manufacture of these nuclear valves. We begin with the materials—every machining operation is accurately gauged—all parts are thoroughly cleaned and degreased—then every valve is not only subjected to an actual line test, but is given a snifter or mass spectrometer test.

Shown here are examples of the types of valves available to industry for use with heavy water, molten metals, etc. For complete information, consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our Nuclear Valves as well as our complete line of Powell Quality Valves—all with Performance Verified.

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES



We're sold on "KARBATE" equipment. It costs less, lasts longer, and it's easier to maintain!



Here's how you save with
**"KARBATE" IMPERVIOUS GRAPHITE
 PROCESS EQUIPMENT**

- Lower first cost
- Sustained low maintenance
- Immunity to thermal shock
- High thermal conductivity
- Rugged mechanical designs
- No metallic contamination
- Ease of installation
- Light weight
- Quick delivery
- Complete technical service
- Outstanding corrosion resistance

No other material of construction combines all the advantages of "Karbate" brand impervious graphite.

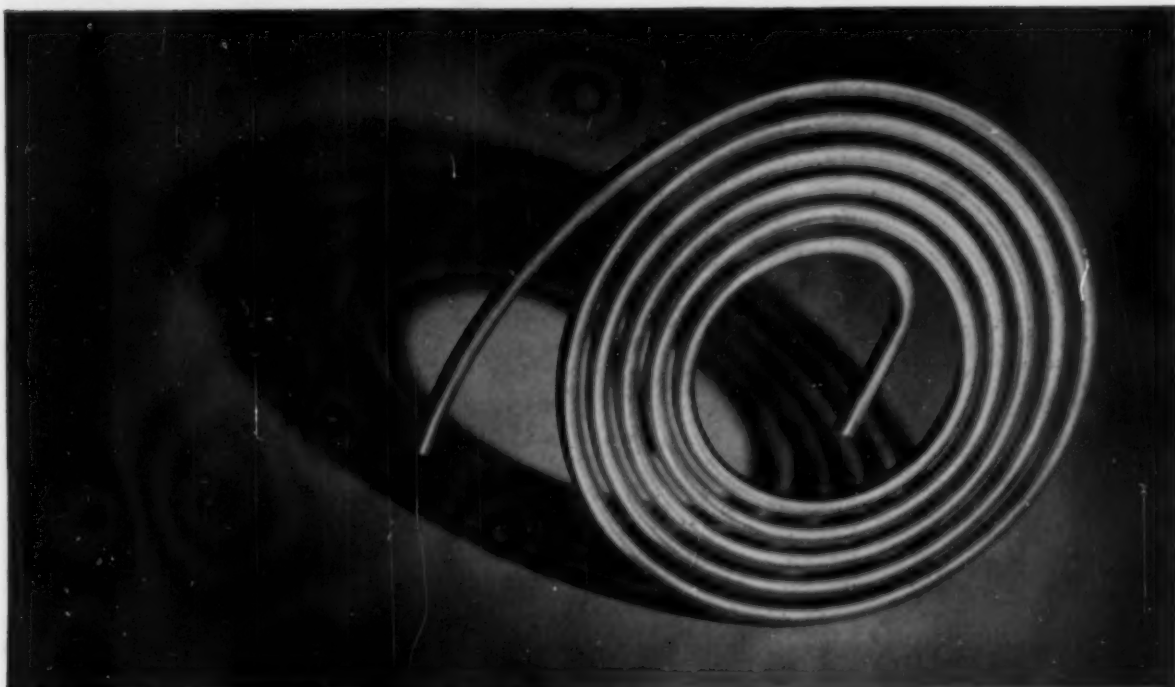
Think of "Karbate" equipment *first* for new plant and expansion; consider it *always* where corrosion is a factor.

Write for Literature • Manufactured only by NATIONAL CARBON COMPANY

The term "Karbate" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY • A Division of Union Carbide and Carbon Corporation • 30 East 42nd Street, New York 17, N. Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. In Canada: Union Carbide Canada Limited, Toronto





Superior offers the widest range of sizes and alloys in top quality instrument tubing

Superior Tube Company produces the finest instrument tubing in a wide range of sizes and alloys—offers you as standard products what many makers would classify as specialty tubing.

1. NEEDLE TUBING

The stainless steel links in this recording instrument are made of Superior needle tubing. The high strength, stiffness, and strict dimensional tolerances characterizing this tubing—originally designed for surgical uses—have opened new fields of industrial applications when used as mechanical tubing.

2. PRESSURE AND SUPER PRESSURE TUBING

A spiral windpipe made of Superior 304 cold-drawn seamless stainless steel tubing. Pressure tubes are used to convey fluids at elevated temperatures and pressures. Produced in stainless, carbon and alloy steels in sizes to withstand pressures up to 100,000 psi.

3. BOURDON TUBING

A "C" tube element for a pressure gage. The shaped Bourdon tube serves as the actuating element for the majority of pressure indicating and recording instruments. Helix and spiral elements are also fabricated from the wide range of alloys available at Superior—a range that makes it

possible to satisfy any set of conditions in the use of Bourdon tubing.

4. CAPILLARY TUBING

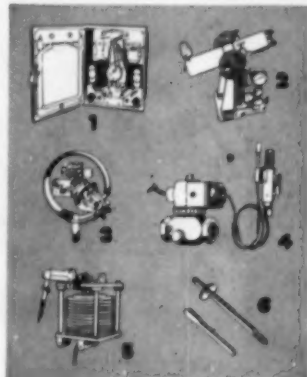
A thermostatic instrument pressure transmission element with a coiled unit made of Superior Type 321, capillary tubing. Superior capillary tubing is used primarily for transmitting temperature and pressure impulses from the source to a recording or indicating instrument. Capillary purposes, in general, require a heavy-wall tube with an ID of .006" to .030". Types 347, 321, 316, MONEL[®] and carbon steels are recommended analyses.

5. LARGE OD LIGHT WALL TUBING

A large OD light wall tubing bellows in a pressure actuating element. Present applications for large OD light wall tubing include bellows, low pressure heat exchanger tubes, flexible hose, aircraft ducting, fractional horsepower motor casings, ceramic drills, and casings for radioactive well logging instruments. Sizes offered up to 2½" OD.

6. MECHANICAL TUBING—INSTRUMENT LINE

Various fabricated parts—all made of Superior mechanical tubing. Superior mechanical tubing can be either seamless or WELDRAWN[®] grade used statically or dynamically, but not subjected to severe temperature or pressure. It is produced in sizes up to ½" OD within production limits, in many special shapes, and in over 63 standard analyses and mechanical properties.



Send for free copy of Bulletin 40—
A Guide to the Selection and
Application of Superior Tubing.
Write Superior Tube Company, 2911
Germanstown Ave., Norristown, Pa.

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium

Superior Tube

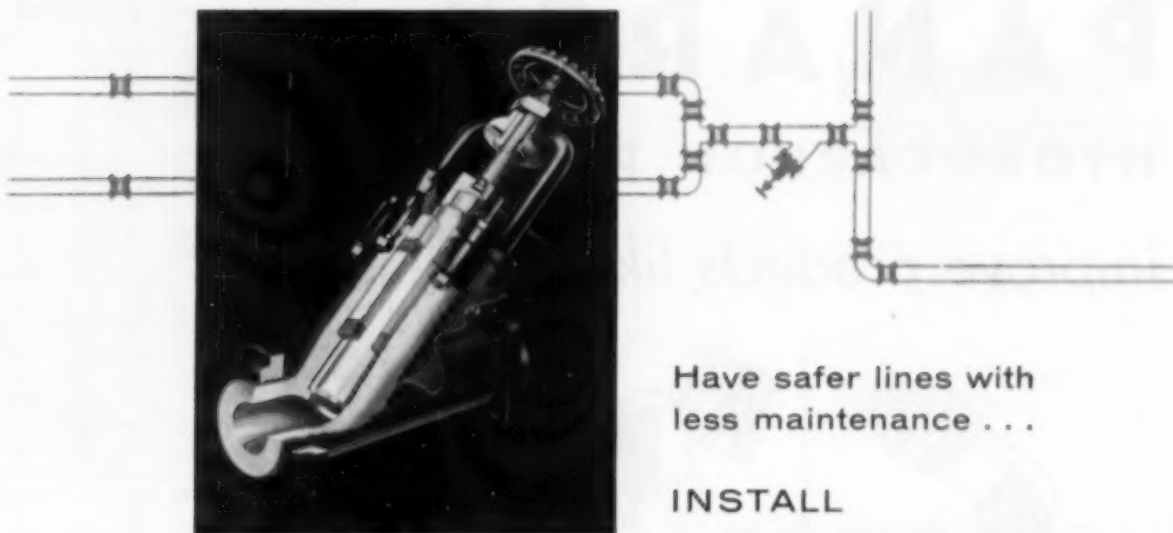
The big name in small tubing

NORRISTOWN, PA.

*Reg. T.M. International Nickel Co.
†Reg. T.M. Superior Tube Co.

All analyses .010" to ½" OD—certain analyses in light walls up to 2½" OD

On the West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif.



Have safer lines with
less maintenance . . .

INSTALL

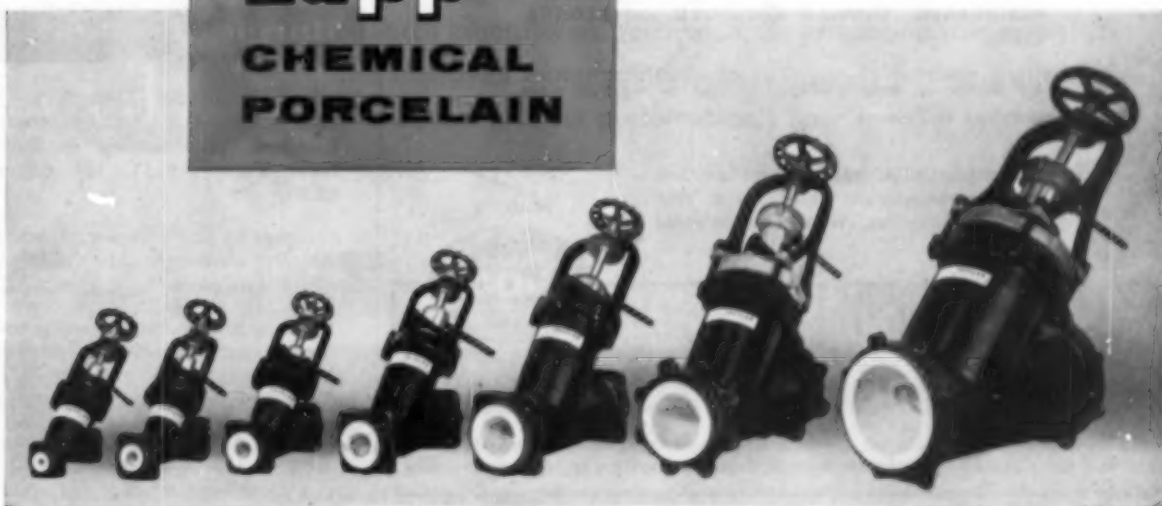
LAPP TUFCLAD®

**SOLID CHEMICAL PORCELAIN ARMORED
WITH FIBERGLASS-REINFORCED PLASTIC**

The extra margin of safety essential to many process plants where protection of personnel, equipment and product is vital is assured by the bonding of TUFCLAD fiberglass-reinforced plastic to Lapp Chemical Porcelain. Strong fiberglass fabric is impregnated and bonded in multiple layers to the porcelain with an Epoxy resin of high strength and chemical resistance. It cushions accidental blows—acts as an insulator against thermal shock—and because TUFCLAD is so strong and tough, it will hold operating pressures even when porcelain is damaged by accident. Specify Lapp TUFCLAD Chemical Porcelain and enjoy the purity and corrosion resistance of a solid porcelain system with extra security from TUFCLAD armor. Y-Valves, as shown, and Angle Valves are available in Lapp TUFCLAD Chemical Porcelain in $\frac{1}{2}$ ", 1", 1½", 2", 3", 4" and 6" sizes. Also safety valves, flush valves, plug cocks, pipe and fittings (to 8" diameter) and special shapes.

*WRITE for description and specifications.
Lapp Insulator Co., Inc., Process Equipment
Division, 834 Wendell St., Le Roy, N. Y.*

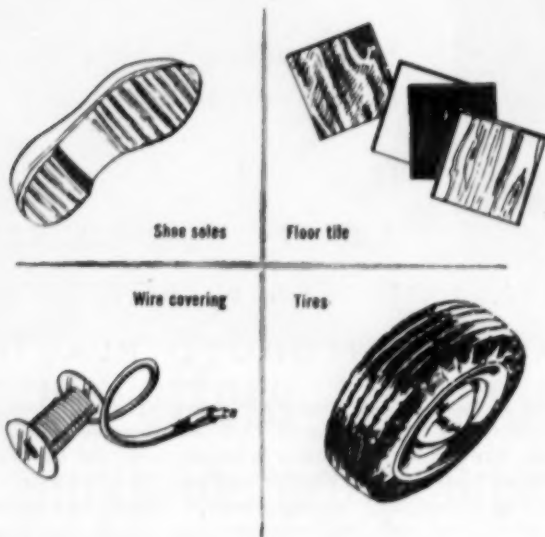
Lapp
CHEMICAL
PORCELAIN



PANAREZ

HYDROCARBON RESINS

improve products like these



If you compound rubber it will pay you to investigate low cost PANAREZ hydrocarbon resins. These softeners are available in any color from Barrett No. 1 to 18, and softening point from 40° F to 300° F. They are supplied in flaked or solid form.

Compounds containing Panarez resins show **IMPROVED COLOR AND COLOR STABILITY . . . IMPROVED EXTRUDABILITY . . . IMPROVED FLEX CRACK PERFORMANCE and ABRASION RESISTANCE . . . IMPROVED OZONE RESISTANCE . . . IMPROVED TEAR RESISTANCE, TENSILE STRENGTH and ELONGATION.**

No change in compounding technique is required when switching to Panarez resins.

For confidential information about how these low cost resins might be helpful in your business, write us, telling the intended application.

PRODUCT OF

AMOCO

**PAN AMERICAN
CHEMICALS**

**PAN AMERICAN
CORP. Chemicals**

555 FIFTH AVENUE, NEW YORK 17, N. Y.

PANAREZ
Hydrocarbon resins

PANAPOL
Hydrocarbon drying oils

PANASOL
Aromatic solvents

Noted and quoted

(Continued from page 10)

Our Need Right Now

What we want is an active class who will insist in season and out of season that we shall have a country whose greatness is measured not only by its square miles, its number of yards woven, of hogs packed, or bushels of wheat raised, not only by its skill to feed and clothe the body, but also by its power to feed and clothe the soul; a country which shall be as great morally as it is materially; a country whose very name shall call out all that is best within us.

James Russell Lowell

April 13, 1888

Reprinted in *Saturday Review*

Licensing

Engineering groups who sponsor legislation should realize that in the broad field of the application of science which they call "engineering," there is more than one background in the field of higher education by which men can become qualified, and that the "engineering school curriculum" is only one of such backgrounds. The practice in the field of science and its application by properly qualified scientists with backgrounds at least equal to in academic stature but different from the "engineering school curriculum" should not be restricted, nor should any one of such backgrounds, including engineering, be permitted legally to preempt the field.

William W. Porter, II,

Chairman, Legislative Committee,
Pacific Section, AAPG,
in "Geological News-Letter"—re-
printed in *The Registration Bulletin*

Marginal notes

Nuclear Radiation Detectors. J. Sharpe. Methuen and Company, London, John Wiley & Sons, New York (1955), 184 pages, \$2.50.

Reviewed by N. W. Snyder, Associate Professor, University of California, Berkeley, California.

The book is of pocket size and is convenient to use. The author has included much quantitative data in the form of tables and graphs and, as a result, it compares favorably with larger works. It is not easily digestible for the begin-

(Continued on page 31)



AS PARTNERS

IN YOUR PROGRESS

OUR EXTENSIVE

RESEARCH
— is a *plus* factor!

Our extensive program in carbon and graphite research is conducted by highly qualified chemists, physicists and technicians.

The scope of their specialized knowledge is a significant *plus factor* in the reliability that distinguishes GLC electrodes, anodes and mold stock.

ELECTRODE



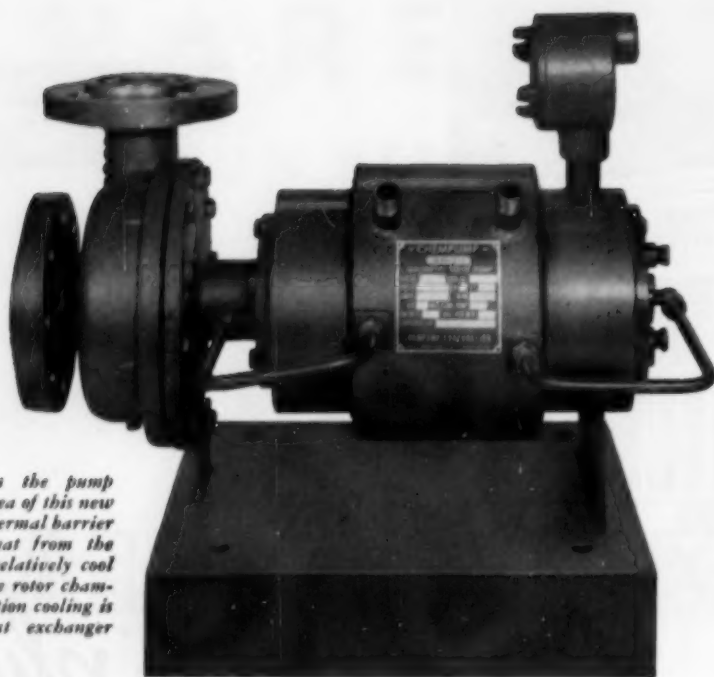
DIVISION

The high degree of integration between discoveries in our research laboratories, refinements in processing raw materials and improved manufacturing techniques is further assurance of excellent product performance.

Great Lakes Carbon Corporation

GRAPHITE ELECTRODES, ANODES, MOLDS and SPECIALTIES

ADMINISTRATIVE OFFICE: 18 East 48th Street, New York 17, N. Y. PLANTS: Niagara Falls, N. Y., Marganton, N. C. OTHER OFFICES: Niagara Falls, N. Y., Oak Park, Ill., Pittsburgh, Pa. SALES AGENTS: J. B. Hayes Company, Birmingham, Ala., George O. O'Hara, Wilmington, Cal. SALES AGENTS IN OTHER COUNTRIES: Great Northern Carbon & Chemical Co., Ltd., Montreal, Canada; Great Eastern Carbon & Chemical Co., Inc., Chiyoda-Ku, Tokyo, Japan



The "neck" between the pump chamber and motor area of this new Chempump acts as a thermal barrier to the transfer of heat from the pumped fluid to the relatively cool fluid circulating in the rotor chamber. Further motor section cooling is achieved by the heat exchanger girdling the stator.

New Chempump handles hot fluids

- No seals . . . no stuffing boxes
- No fluid loss or contamination
- No lubrication . . . 90% less maintenance
- Just one moving part

Now you can pump heat-transfer fluids, hot vegetable and mineral oils, silicone fluids—without leakage . . . without contamination, even under extreme vacuum or pressure! This new Series T Chempump ends the problems of transferring or circulating such hot "problem" fluids as Dowtherm, Arochlor, fatty acids, vegetable oils or others.

Pump, motor and heat exchanger are combined in a single, compact hermetic package. Pump impeller and rotor are an integral unit—Chempump's only moving part.

Fluid enters the rotor chamber, and is completely isolated from the stator section by a corrosion-resistant, non-magnetic liner. A portion of this fluid is continually re-circulated in the rotor chamber and through an integral heat exchanger by an auxiliary impeller, to cool the motor. Pressure balance at the "neck" prevents intermixing of fluid in the motor section and fluid in the pumping section while the Chempump operates at a steady state. Motor windings keep cool, yet there's no heat loss of pumped fluid.

No shaft-sealing device is needed. Normally hard-to-handle fluids—hot, volatile, toxic, corrosive, explosive, radioactive—just can't leak or become contaminated.

Get the facts. For details and application data, send for new Bulletin 1040.

SPECIFICATIONS

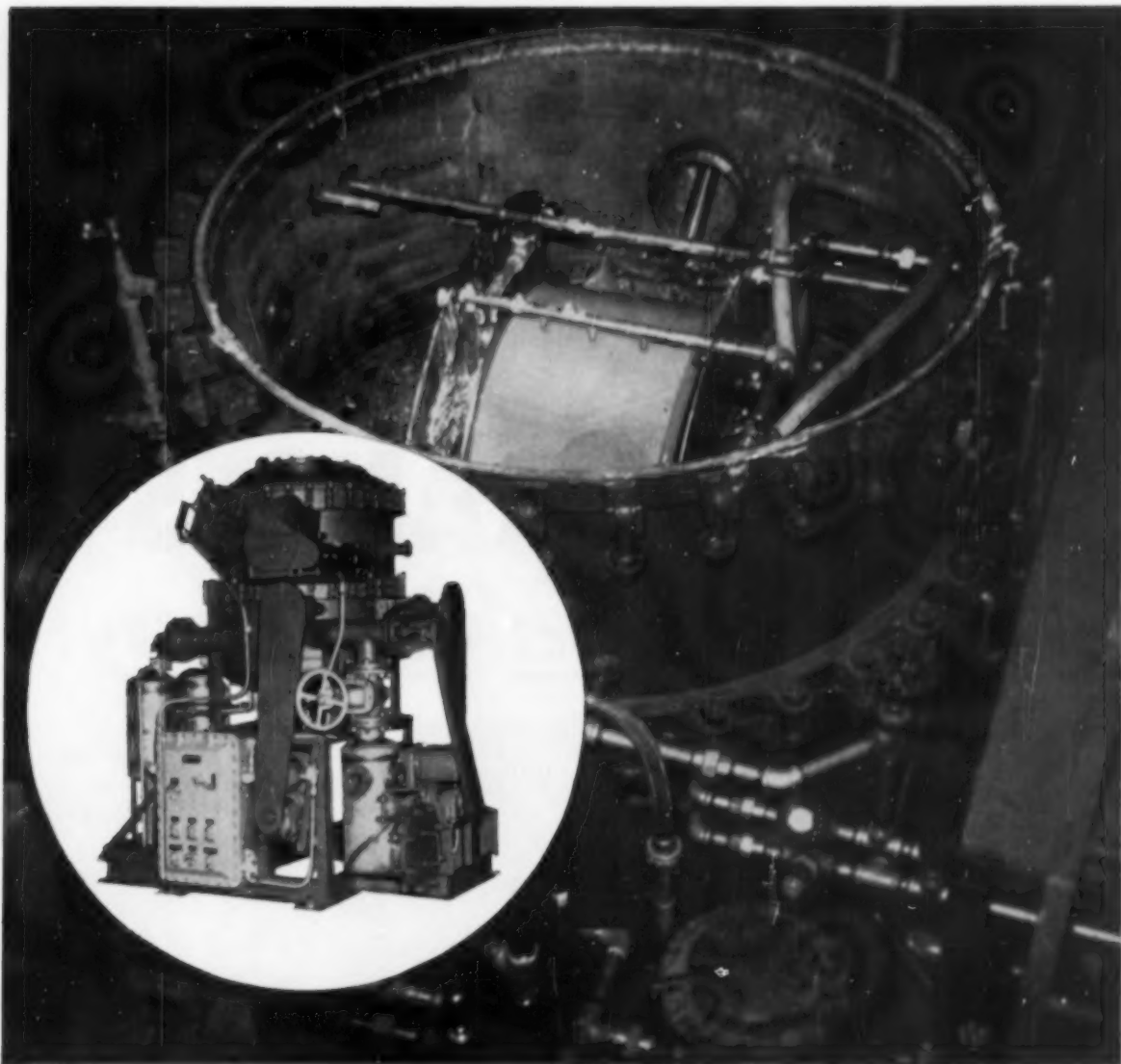
| | |
|----------------------------|---|
| Horsepowers . . . | $\frac{3}{4}$ to $7\frac{1}{2}$, in 6 models |
| Heads | to 190 feet (maximum) |
| Capacity | to 200 GPM (maximum) |
| Materials of construction* | cast iron, cast steel, 300-series stainless steel |
| Temperature limit* | 1000°F. |
| Pressure limit* | 150 psi |

*Standard. Designs for higher temperatures or pressures, or using other construction materials, available on special order.

Chempump

First in the field . . .
process proved

CHEMPUMP CORPORATION • 1300 E. Mermaid Lane • Phila. 18, Pa.



WE CAN'T SEND A SAMPLE

Eimco's Research and Development Center has the answer for the plants with difficult filtration problems. The engineers at the Center know that under certain product conditions it is unwise for the laboratory to try to reproduce plant conditions in which the sample was taken.

The alternate is to provide test equipment at job site suitable for wide range filtration problems. Eimco has designed several units similar to the unit shown above that can be used as standard drums, precoat drums, pressure drums and pressure precoat drums. These units are also equipped for washing and can use several types of cake removal attachments.

Eimco's experience in over half a century of service to process industries has given them the advantage of understanding filtration problems. The need for developing and producing numerous types of filtration equipment gives Eimco more opportunity to serve the customer's needs.

Eimco's objectives are: 1. To solve the customer's filtration problem successfully. 2. To recommend the most practical and economical equipment suited to the job, and, 3. To give a stand-by consulting service in securing maximum benefits from the equipment.

Yes! When you have a problem in filtration, Eimco can help whether or not you can send a sample.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A.

• Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Baltimore, Md. Pittsburgh, Pa. Seattle, Wash. Pasadena, Calif. Houston, Texas Vancouver, B. C. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

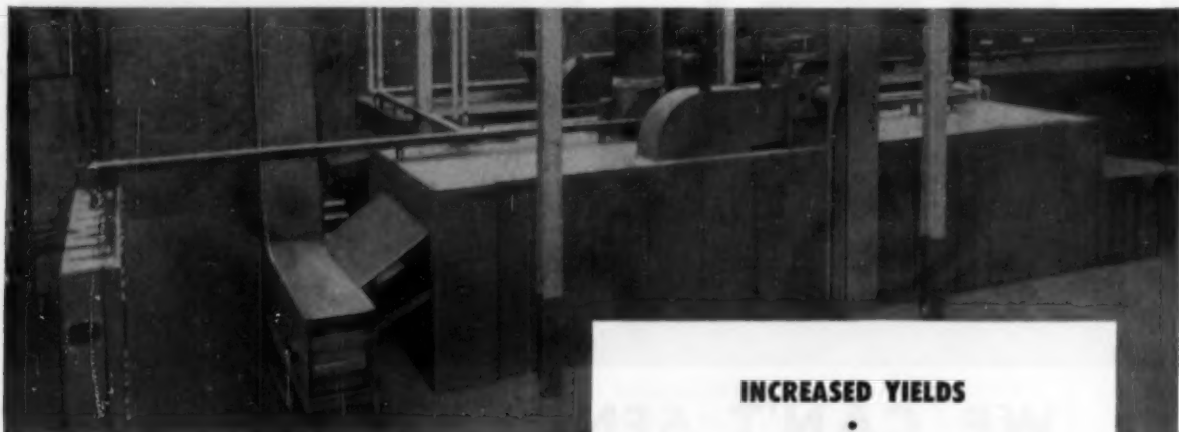


B-107



DRYING RANGES

for
highest product uniformity!



PRODUCT UNIFORMITY is of utmost importance to every food processor, at all stages of processing. The Proctor continuous conveyor dryer installation shown above is located in a plant of one of the world's largest food manufacturers—typical of many in use in the food industry today. In this plant Proctor Dryers assure uniformity of color, taste, and high customer appeal—yields are greatly increased!

WITH UNIFORMITY COMES PROFIT. Efficient drying per pound of product can often mean more direct profit than an increased sales volume. Proctor equipment provides the control, flexibility and construction features *essential* to profitable drying performance. Write or phone today for complete information.

INCREASED YIELDS
•
GUARANTEED QUALITY OF PRODUCT
•
FLEXIBILITY
•
PROFITABLE OPERATION

**OTHER PROCTOR DRYING EQUIPMENT FOR THE
FOOD AND PROCESS INDUSTRIES**

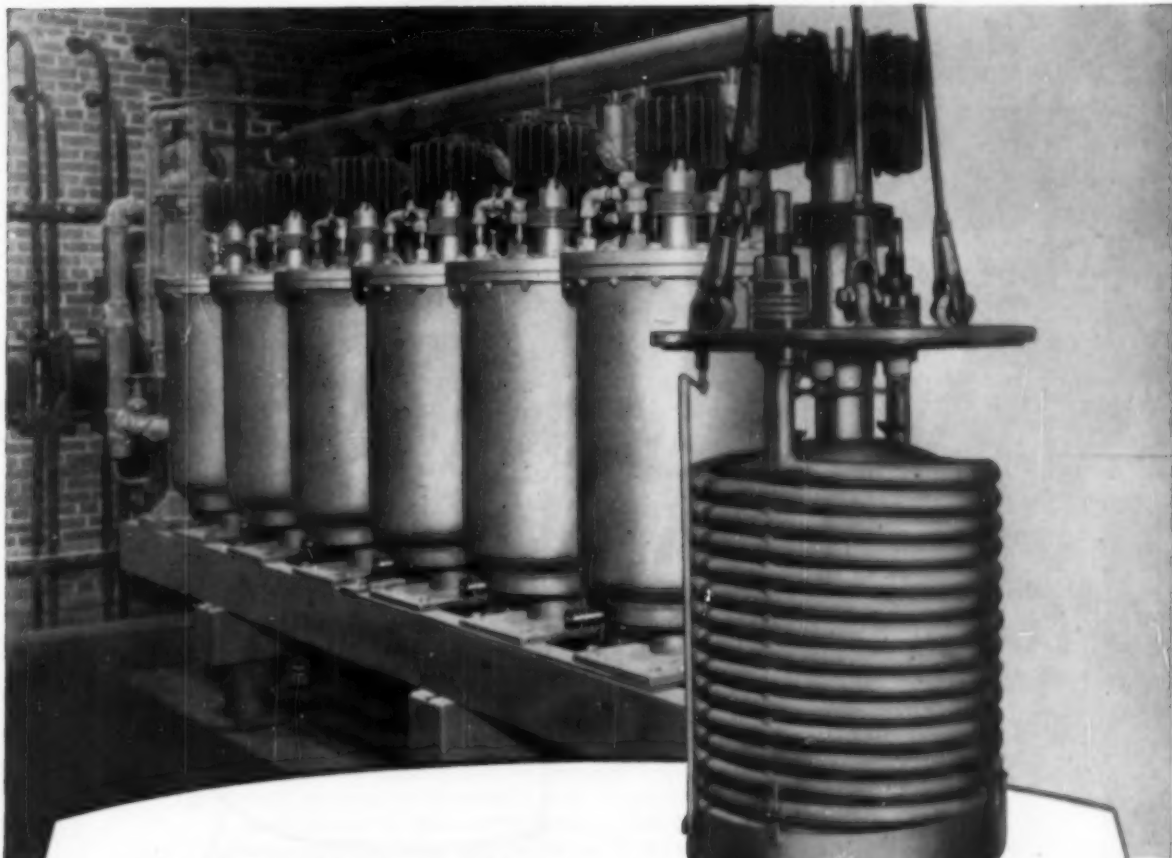
**TRAY DRYERS • TRUCK DRYERS
PRE-FORMING FEEDS • SPRAY DRYERS**

PROCTOR & SCHWARTZ, INC.

Philadelphia 20, Pa.



MANUFACTURERS OF INDUSTRIAL
DRYING EQUIPMENT
AND TEXTILE MACHINERY



**Why Allis-Chalmers Cooling
Coil Design Means . . .**

Better Rectifier Operation

More Efficient Heat Transfer results from internal cooling coil. The steel coil surrounds active parts, offering more cooling surface and better heat transfer than other types. Unit maintains more uniform temperature and mercury vapor pressure.

Simplified Maintenance results from Allis-Chalmers unique unit construction. All active components are attached to the anode plate for easy withdrawal, dismantling, and re-assembling — as illustrated above.

Positive Arc Barrier is formed by the cooling coil, which is insulated from the tank. The main arc is confined within the coil, preventing arc transfer to the tank.

Years of Operation in hundreds of installations have proved the reliability, ease of operation, and simplified maintenance of Allis-Chalmers mercury arc rectifiers. You can get complete information at your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.



ALLIS-CHALMERS



A-5064



Congratulations Dad...it's a valve!



Maybe this is not the way to say it, but we know that every time a new design feature is created to solve a field service problem, hundreds of plant engineers, chemical engineers, maintenance men and purchasing agents look

on with the pride of a new father. Our engineering department is the first to admit that the major part of new stainless steel valve design comes from the interchange of problems and experience at our various valve clinics.

Cooper Alloy Area Valve Clinics have been held in most major industrial centers, and our in-plant

clinics have been held on the spot in dozens of leading plants, including Dow, DuPont, Mathieson, Celanese, Pfizer and many others. At these meetings our staff presents its findings, listens to the findings of users, specifiers and buyers, and attempts to work out specific problems.

Arrangements for such a clinic in your own plant may be made through our Public Relations Division.

"75 Questions" . . . a selection of those questions asked most often at our clinics, is available on request.

Valve & Fitting Division



COOPER ALLOY
CORPORATION • HILLSIDE, N. J.

PROGRESS THROUGH CHEMISTRY

Davison...leader in Silica Gel

Davison pioneered in the development of the first commercially useful silica gel more than three decades ago, and for years has been America's leading producer. Silica gel, with its porous amorphous physical structure providing a surface area of 90,000 square feet per cubic inch, is a unique compound of continuing importance and increasing application. Silica gel's most important properties are its ability to condense and retain condensable gases in the porous structure and its regenerable nature through the application of heat or other elutriation methods. A wide variety of particle sizes, densities and adsorptive capacities are available, each having been developed to meet specific application demands. Investigate Davison Silica Gel, now.

See your Davison Field Service Engineer or write for technical literature.

DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

Baltimore 3, Maryland



Sales Offices: Baltimore, Md.; Chicago, Ill.; Columbus, Ohio;
Houston, Texas; New York, N. Y.

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates,
Phosphate Rock, Silica Gels, Silicofluorides;
Sole producers of DAVCO® Granulated Fertilizer.

ask for . . .



Davison Silica Gel
for the dehydration
of air and gas.



Syloid® 308 . . .
lacquer flattening
agent.



Syloid® AL-1 . . .
prevents gas build-
up in metallic paint.



Protek-Sorb® 121
... for Method II de-
hydrated packaging.



Syloid® 162 . . .
alkyd-urea varnish
flattening agent.



Syloid® 244 . . . superior
flattening agent in clear
alkyd finishes and
oleoresinous varnish.

Typical Mechanical Properties of Ni-Vee Bronzes

| TYPE | A (lead free) | | | B (1% lead) | | C (5% lead) | | D (10% lead) | | E (20% lead) | |
|-------------------------------------|------------------|----------|--------------|----------------|----------|----------------|----------|-----------------|----------|-----------------|----------|
| | As Cast | Tempered | Heat-Treated | As Cast | Tempered | As Cast | Tempered | As Cast | Tempered | As Cast | Tempered |
| Tensile Strength (thousand psi).... | 50 | 65 | 85 | 45 | 60 | 40 | 50 | 35 | 40 | 25 | 30 |
| Yield Strength (thousand psi)..... | 22 | 40 | 55 | 20 | 30 | 20 | 30 | 20 | 25 | 18 | 22 |
| Elongation, % in 2"..... | 40 | 10 | 10 | 30 | 8 | 15 | 5 | 10 | 2 | 5 | 2 |
| Brinell Hardness..... | 85 | 130 | 180 | 80 | 120 | 80 | 130 | 80 | 110 | 70 | 80 |

Specifying is simple and systematic with 5 versatile Ni-Vee Bronzes

Now . . . designers and engineers can readily select a suitable bronze for any specific need . . . from only five Ni-Vee* bronzes.

"As Cast," these five Ni-Vee bronzes provide mechanical properties that surpass those of comparable G bronze, red brasses and leaded bearing bronzes. What's more, their superior properties can be still further elevated by simple heat-treatments.

Basically, each Ni-Vee bronze contains 5% nickel and 5% tin, from 0 up to 20% of lead. Tensile strength ranges from 25 to 85 thousand psi, and hardness from 70 to 180 Brinell.

Advantages

Just five of these Ni-Vee bronzes make it possible to standardize metal inventories, melting practices and shop operation . . . as well as specification . . . to meet many industrial uses for copper-base castings.

Each Ni-Vee bronze contains an optimum nickel content to raise levels of strength, hardness and toughness. In addition, this nickel content provides a high degree of corrosion resistance in the Ni-Vee bronzes. Negligible zinc content makes it free from dezincification. This spells resistance to stress-corrosion attack.

A versatile family

Copper-base alloys are ordinarily used for the three types of castings listed below. For each of these applications a Ni-Vee bronze provides particular advantages:

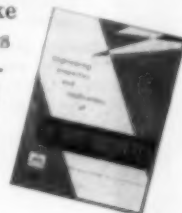
- (1) **Constructional** castings — high strength
- (2) **Pressure** castings — fine grain
- (3) **Bearing** castings — resistance to wear and seizure

The simple family of five Ni-Vee bronzes actually replaces the confusing variety of miscellaneous bronzes. As a result, engineers and designers can now specify simply and systematically . . . specify Ni-Vee bronzes wherever possible. Parts cast in Ni-Vee bronze already serve electrical, power, steel, petroleum, chemical, automotive, aircraft, railroad and other industries.

Engineering data for you

Learn how the Ni-Vee bronzes can simplify your specification work, improve product performance. Send for a copy of "Engineering Properties and Applications of Ni-Vee Bronzes." It contains useful information like that given in the table above: tables of composition, charts on deformation, friction, fatigue, elevated temperature service, electrical resistivity, wear and other engineering data. Write for it now.

*Registered trademark



THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street
New York 5, N.Y.

**"No other group could
have done a better job
than **GIRDLER**"**

**reports Texas Eastman Company
about Girdler's Engineering Service**



IN 1954, Girdler engineered and procured the equipment for the Longview, Texas, polyethylene plant of the Texas Eastman Company, a division of Eastman Kodak.

After the plant was in operation, Texas Eastman's engineering management reported: "The polyethylene plant has operated extremely well, thanks in a large part to the very fine job everyone at Girdler did for us. Time and again, we can see where the thought that went into the layout and piping up of equipment has paid off in a very large way. We know that no other group could have done a better job, and it is highly unlikely that anyone would have done as well as Girdler."

And Now . . . Girdler Selected Again

Texas Eastman is now expanding this Longview plant. And the above comments point up why Girdler has been selected for engineering and procurement of equipment and materials for the new facilities as for the original plant. Texas Eastman—like so many leading companies in the chemical, petroleum, plastic materials, food and fertilizer fields—has found that Girdler's broad experience results in outstanding process performance for them.

When you plan plant expansion or modernization, take advantage of Girdler's *complete design-engineering-construction* service. You can get all the facts by contacting our nearest office.

The **GIRDLER** *Company*

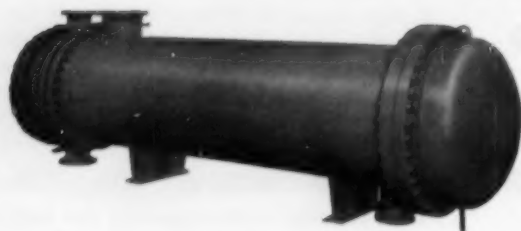
A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

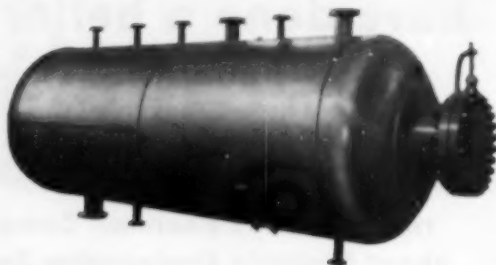
GAS PROCESSES DIVISION...Design, Engineering, Construction of Hydrocarbon Processing Plants, Gas Plants, Chemical Plants. Offices: New York, San Francisco

WHITLOCK PROCESS EQUIPMENT

... for every processing purpose!



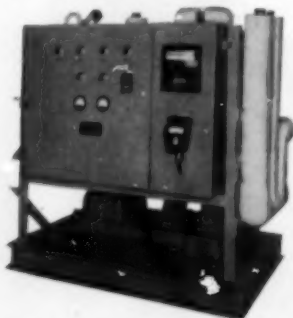
HEAT EXCHANGERS Whitlock manufactures a complete range of heat exchangers for every processing requirement. Standard designs include: Straight Tube and U-Tube, and Coil and Double Pipe types.



PRESSURE VESSELS Where engineering design is important — for special operating conditions, longer service, or lower maintenance costs — a Whitlock Engineer can help you select the right Pressure Vessel to meet your exact needs.



COILS Whitlock is fully equipped to fabricate coils of any size or material and to assemble and test them hydrostatically or by "air under water". Whether your process demands standard or special configurations, Whitlock can meet your requirements quickly and economically.



"PACKAGED" PROCESS SYSTEMS Whitlock is regularly "packaging" complete assemblies to handle typical process problems as in the case of this transfer oil heating system. Included are standard heat exchangers and vessels with complete operating controls for simple plant installation permitting immediate operation.

In addition to manufacturing standard sizes and types of Heat Exchangers, Whitlock is fully equipped to design and build specially constructed Exchangers for both high and low temperature services and for operating pressures ranging from a complete vacuum to several thousand pounds per square inch. Through long experience, Whitlock Engineers have developed special techniques

for welding all standard materials as well as combinations of dissimilar metals such as aluminum to bronze and nickel to carbon steel. For complete information, write The Whitlock Manufacturing Company, 97 South Street, West Hartford 10, Connecticut. In Canada: Darling Brothers, Ltd., Montreal.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

Marginal notes

(Continued from page 20)

ner, but it is conveniently crowded with a great deal of useful material for the designer and the intelligent user of nuclear radiation instruments. The emphasis is on the physical foundation of detector elements giving the theory of detection processes and the performance of the detector elements. It does not mention auxiliary apparatus, such as pulse amplifiers, scalars, or the use of the complete instrument. Some constructional features of instruments are shown schematically without detail. Certain instruments like bubble and cloud chambers and photographic emulsions are not mentioned since the instruments discussed are those which can be used with electronic recording devices.

The subjects discussed include the interaction of nuclear radiation with matter, detection media, efficiency of detectors, secondary emission and scintillation counters, and ionization devices.

The book is an excellent and accurate reference for the engineer who will work with nuclear radiation detection instruments. It is highly recommended.

The Chemical Industry in Europe.

A study prepared by the chemical products committee. Published by Organization for European Economic Cooperation. Paris, 2 Rue Andre-Pascal (1955), \$1.50


Reviewed by Robert Frank, Foster D. Snell, Inc., New York, New York

The organization for European Economic Cooperation has published its second study on the chemical industry in Europe, covering the year 1954. The international committee charged with this study has widened the scope as it had been suggested after the first report. The statistical information, which was anticipated, is still rather sketchy and is more concerned with percentage changes in production than with absolute data. Thus, the picture shown requires careful interpretation and leads often to misunderstanding of the real situation.

That the general trend of the chemical industry has been ahead of total industrial production in 1954 was true in Europe as it was in the United States, but to show on a diagram that Greece and Norway have been twice as far ahead of the crowd is, to say the least, misleading. The reporting of the production of individual chemicals within

(Continued on page 34)

**good insurance
policy**
for Your Chemical Piping



Chemiseal®
**EXPANSION JOINTS
FLEXIBLE COUPLINGS**
® made of duPont TEFLON

... now the "policy" of many Processing Plants

Protect costly piping, usually low in impact strength, against shock, vibration, expansion and contraction. Save their cost in pipe maintenance.

Chemically impervious, non-contaminating (TEFLON).

Eliminate slip-joints, gaskets, adaptors. Made to mate with any companion flanges.

Standard Sizes from 1/4" to 10" I.P.S.
Ask your U. S. Gasket-Belmont Packing Distributor or write for Catalog EJ-1155.

UNITED STATES GASKET CO.

Camden 1, New Jersey



U.S. GASKET · BELMONT PACKING

Are the Solids in Your Process Giving You Trouble?

Are you looking for higher concentration of the solids phase? ... more effective control of solids concentration? ... better clarity? ... higher capacity? ... concentration regardless of feed rate? ... PLUS CONTINUOUS OPERATION?

Then you want to talk with Sharples, for Sharples offers three different high capacity automatic solids discharging centrifuges from which to choose the best for your process requirements.

Take advantage of the Sharples process laboratory, where your material may be run in full sized centrifuges to determine positively the one best answer to your problem. The place to start? Tell us your problem and we'll carry on from there.

You can depend on Sharples

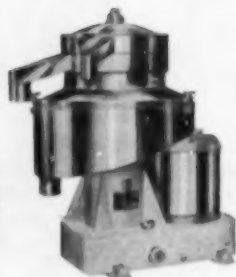


THE SHARPLES CORPORATION

2300 WESTMORELAND STREET • PHILADELPHIA 40, PENNSYLVANIA

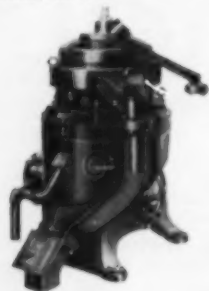
NEW YORK • PITTSBURGH • CLEVELAND • DETROIT • CHICAGO • NEW ORLEANS • SEATTLE • LOS ANGELES • SAN FRANCISCO • HOUSTON

Associated Companies and Representatives throughout the World



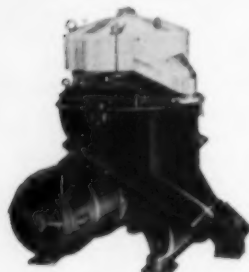
**DH-3 High Capacity
NOZZJECTOR**

... continuous nozzle discharge for concentration of large quantities of solids such as starch, gluten, phosphoric acid, antibiotics, etc. ...



DG-2 AUTOJECTOR

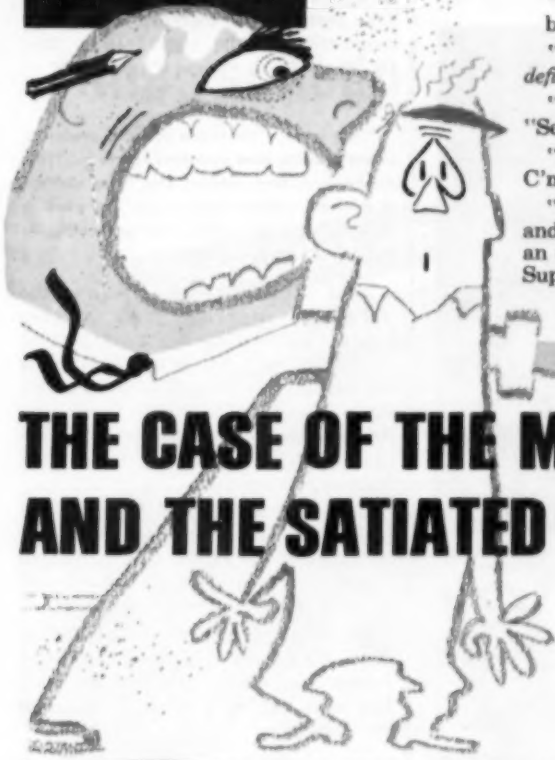
... solids discharge automatically controlled and varied by concentration of solids in feed stream as in processing protein concentrates, linseed oil, wool scouring liquor, etc. ...



THE DV-2

... automatic solids discharge is controlled as desired by means of external clock timers. The DV-2 has wide use for processing pineapple juice, vegetable purees, protein liquors, etc. ...

S/K apades in industry



"I'M FED UP!" screamed Simpkins, the Superintendent. "I've had it, and I'm fed up. That mixer has GOT To Go!"

"But boss," soothed Barney, the Bird Dog Assistant, "that mixer can't be shut down. The Front Office has already told us..."

"Out!" interrupted the seething Super.

"...that if we can't spark up production, changes are gonna be made," finished Barney.

"YOU'RE RIGHT," said Simpkins coldly. "You're so absolutely, definitely right. Changes are gonna be made—Now!"

"Can't we talk this over, man-to-man?" mumbled Barney. "Seems to me..."

"Sure we can talk it over," said the Super, "sure we can. C'mere m'boy. I'll talk, and you listen."

"You've got two weeks. Two weeks to GET THAT MIXER OUT and something an awful lot better in. That's your mission, boy, an out and out case. The mixer or you. Think it over," said the Super, with a man-to-man pat on the back.

THE CASE OF THE MACHIAVELLIAN MIXER AND THE SATIATED SUPERINTENDENT



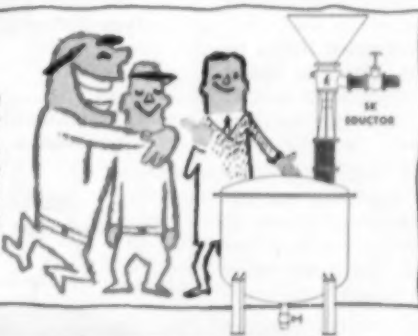
"...need your help," phoned Barney to his nearest SK Sales Engineer. "I've thought over this problem I've told you about, read SK's Bulletin J-1, and I think a jet of some kind is right for the job."



"YOU'RE RIGHT," replied SK's nearest Sales Engineer. "You're so absolutely, definitely right. An SK Water Jet Eductor will do the job, and I'll be right over to tell you how."

NO BIRD DOG NOW

Now, thorough mixing of dry powder and a liquid prior to discharge into a tank is accomplished by the use of an SK Fig. 235 Eductor as shown. Pressure liquid enters the eductor, entrains the powder, mixes the two in the venturi of the eductor and discharges the mixture into a receptacle. The streamline design provides maximum efficiency. No bird dog now, Barney is consulted on every production problem—howls with Simpkins every Thursday night.



MORAL:

Get acquainted with all types of SK Jet Apparatus. Send for a copy of Condensed Bulletin J-1. Make use of a qualified specialist, your nearest SK Sales Engineer.



Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS

2245 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 10-RA.
VALVES: Ask for Condensed Bulletin W-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin RT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

TANK CAR RUPTURE DISC PROBLEMS?



Model TC Rupture Discs are used for overpressure protection on tank cars under 103-A, 103-B, 103-AW and 103-BW classifications. The car shown above was built by American Car & Foundry Division of ACF Industries, Incorporated, and is owned by Shipper's Car Line Division of the same company. Lessee is Niagara Alkali Company.

New BS&B Model TC Rupture Disc Will Not Corrode Or Fatigue While Car Is In Transit!

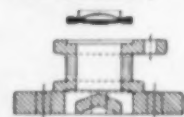
Here's a new Tank Car Disc by BS&B which meets the demand for a serviceable disc that will not corrode or fatigue while the car is in transit!

Engineered and manufactured by the nation's leading and oldest manufacturer of rupture discs and related equipment, the Model TC prevents unnecessary product loss and lowers maintenance costs for tank car shippers. Loadings reach their destination safely and without delays.

Adaptable to either standard bolted or threaded type tank car fittings, Model TC is thoroughly tested and proved through service by tank car builders and chemical shippers.

Available in 30 psig. and 45 psig. relief pressures. Assembly into tank car fittings conforms to sketches shown at right. Discs are furnished for tank car fittings of any design. For more information, address your inquiry to...

Adaptable To Either...



Standard Bolted Type Fitting Or...



Threaded Type Fitting



BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-DX7
7500 East 12th Street, Kansas City 26, Mo.

Marginal notes

(Continued from page 31)

each country is rather vague. The basic chemicals, organic as well as inorganic, have been lumped together for the determination of the trend rather than for exact data.

The study states as follows:

"Only seven of the twelve countries producing calcium carbide have submitted figures for 1954. As, however, they produce over three quarters of member countries total output, any trend in these figures would apply, in all probability, to the O.E.E.C. area as a whole."

Then, a mathematical average of the increase in production index is taken and an increase for the total area of roughly 15 per cent is assumed, while the increases in the individual countries range from 4 to 72 per cent. Since similar assumptions form the basis for other conclusions too, the whole approach appears wrong.

The appendix contains several tables with information on production and consumption of sulfur and nitrogen which have probably not been collected in such detail anywhere else.

Basically, it appears that a lot of good effort has been wasted in collecting information, which could be valuable but has been lost in a mire of statistical evaluation.

Proceedings—Second General Assembly, Engineers Joint Council, New York, 68 pages, (1955) \$1.

This pamphlet is a discussion of the Reserve Forces Act of 1955 by top representatives of the Selective Service Department of the Department of Defense, Office of Defense Mobilization, and the findings of the Hoover Commission.

American Universities and Colleges, 7 ed. Edited by Mary Irwin. American Council on Education, Washington, D. C. (1956), 1,210 pages, \$12.00.

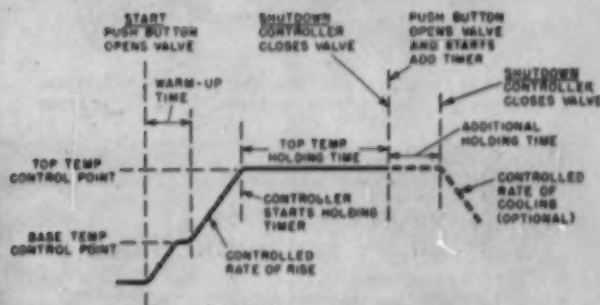
This edition of "American Universities and Colleges" brings up to date classic reference for student counselors, college administrators, researchers, and writers. It provides full descriptive data on 969 accredited universities and colleges in the United States, Alaska, Hawaii, and Puerto Rico—seventy-two new accreditations since the 1952 edition. Seven chapters on the administration and organization of higher education in the United States constitute another important feature.

"Push-button" automatic control for complex time-schedules!

• no cam to cut

• schedules reproduced exactly by push button

• schedules changed instantly by turn of knob



With the Foxboro CycleLog Controller you can establish intricate control programs for process variables with a "twist of the wrist" . . . change them just as easily! You merely "dial" starting point, rate of increase to holding point, holding time, and rate of decrease to shut-down. A push button starts automatic control of cycle . . . repeats it precisely, as often as desired.

Such bothersome industrial control problems as simple batch polymerizations, dissolvers, rubber processing (to name just a few) are being solved every day with this compact, flexible system. No more spoiled batches, "off-spec" product, or expensive re-runs. Operators report better quality, better uniformity, and increased production. And it all adds up to more efficient, profitable manufacturing.

Your nearby Foxboro Field Engineer will be glad to discuss, at your convenience, how CycleLog Control can be used to advantage on your processes. Why not give him a call, or write for details today to The Foxboro Company, 937 Neponset Ave., Foxboro, Massachusetts, U.S.A.

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CREATIVE INSTRUMENTATION
for Process Automation

Pump standardization

1

YOUR CHOICE OF
MATERIALS OF CONSTRUCTION



All iron



All bronze



All Worthite



Iron with bronze
impeller and trim



Steel with iron
impeller and trim



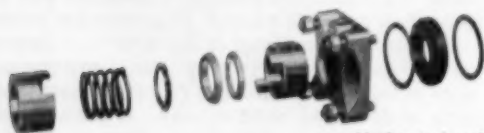
Steel with bronze
impeller and trim

3

YOUR CHOICE OF
SHAFT SEALING METHODS



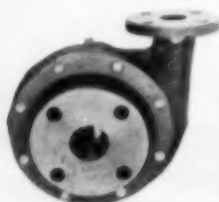
Stuffing box



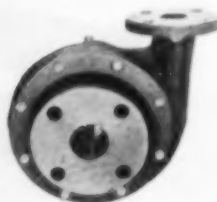
Mechanical seal

2

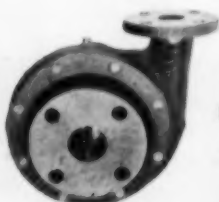
YOUR CHOICE OF
LIQUID ENDS



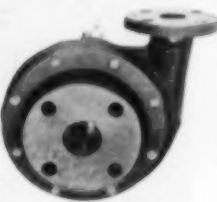
With closed
impellers for
general service



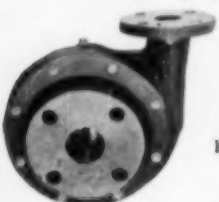
With open impellers
for general and
abrasive services



With closed
impellers for
process service



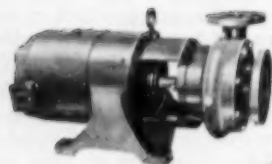
With open
impellers for
corrosive services



With closed
impellers for
hotwell service

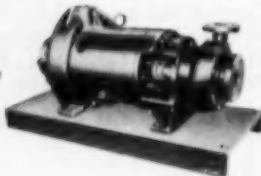
4

YOUR CHOICE OF DRIVES

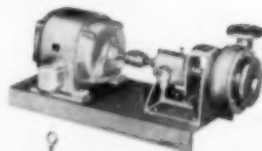


Monobloc Motor

Monobloc Turbine



CLOSE-COUPLED



Direct Motor Drive



Direct Turbine Drive



Belt Drive

FRAME-MOUNTED

Choose from 70,480 combinations. Worthington's SESC—Standard End Suction Centrifugal—line allows you to "custom-build" your pump from stock parts. In each of the 120 sizes, you have a choice of ma-

terials of construction, types of liquid ends, shaft sealing methods, and drives. Because the SESC line is built from standard, stocked parts, you get prompt delivery at competitive prices.

slashes inventory, reduces downtime, cuts maintenance

...yet gives you 70,480 combinations to choose from

STANDARDIZE AND SAVE! NOT SOMETIME IN THE FUTURE, BUT NOW!

With Worthington's SESC—Standard End Suction Centrifugal—line, you can cut your warehousing and inventory costs as much as 50%, greatly simplify pump maintenance, and reduce downtime.

You get these benefits *without* sacrificing flexibility. In fact, the SESC line gives you an even broader selection. Because *parts* have been standardized and not *pumps* you can literally "custom-build" your pump to get exactly the right features for your particular application.

The complete Worthington SESC pump line consists of six separate types, all suitable for either motor, turbine, or belt drive. Ratings range up to 2700 GPM and 230 ft. head. Pumps and spare parts are available from field stock in all strategic areas as well as from the factory.

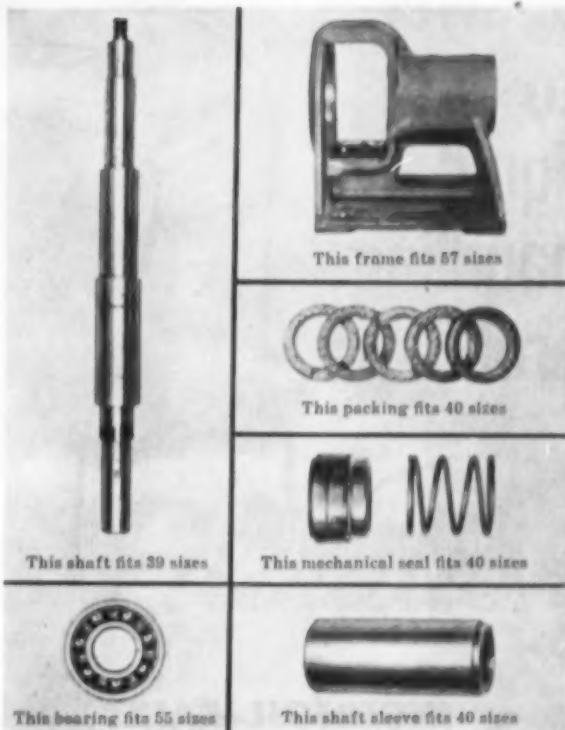
If you'd like to know more about the SESC line, write to Section PC61, Worthington Corporation, Harrison, N.J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

PC&1

WORTHINGTON



Reduces downtime. Parts interchangeability can mean big savings. When repairs or conversions are necessary, standardization can often drastically cut downtime. For example, all SESC pumps can quickly be converted from packed stuffing box to mechanical seal and vice versa using *stock* parts.



This shaft fits 39 sizes

This frame fits 57 sizes

This packing fits 40 sizes

This mechanical seal fits 40 sizes

This bearing fits 55 sizes

This shaft sleeve fits 40 sizes

Slashes parts inventory. You can cut inventory costs as much as 50% by standardizing on the SESC—Standard End Suction Centrifugal—line. In the 120 sizes in the complete line, many, many parts are interchangeable. As shown here, one shaft is used in 39 sizes, one bearing in 55 sizes, one frame in 57, one packing in 40, one mechanical seal in 40, and one shaft sleeve in 40 sizes.



Cuts maintenance. If you know one SESC pump, you know them all. From the smallest to the largest the entire line is built to the same basic design. Maintenance men quickly become familiar with construction details. Their work is simplified and maintenance costs greatly reduced.

the
powerful
answer
to your
liquid
handling
problems



INGERSOLL-RAND

MOTOR PUMP

When production lags because of inadequate pumping facilities, you need the dependable power of an Ingersoll-Rand Motorpump. These pumps are designed for deliveries of from 5 to 2800 gallons per minute, they operate in any position and being compact, save floor space as well!

I-R Motorpumps are efficiently designed for economical performance and ruggedly constructed to stay on the job with a minimum of maintenance.

To get all the details on I-R Motorpumps in sizes from 1/4 to 75 hp, write for complete catalog data.

Ingersoll-Rand

9-421

11 Broadway, New York 4, N. Y.

About our authors

HEADLINERS this month are Neil Kelly and Leonard Swenson, authors of our special feature article



"Comparative Performance of Cooling Tower Packing Arrangements."

Both are engaged in the research program at Pritchard which has provided the basis for this unusual paper, the first of a series. Leonard's explanation of his interest in the subject included: "The study of individual drops has been of paramount interest for many years. I improvised atmospheric cooling of drinking water during military service in the Philippines with the 7th Division."



NOW IN THE RANKS of V.I.P.'s is Jack Tielrooy, author of "The Importance of Complete and Accurate Capital Cost Estimates" (C. E. P., May 1956).

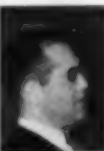


Jack has since publication of the article been elected to the Board of Directors and Executive Committee of Brea Chemicals, Inc., where he was manager of development—a position he will continue to fill.

WHEN G. P. MONET of DuPont's Experiment Station presented his paper "Experiences with Mixed Bed Deionization" at the Houston A.I.Ch.E. Meeting, he charmed his audience with color motion pictures of the backwashing, separation, and other steps of the exchanger operation cycle. The reaction of a certain Committee was so favorable that he was awarded the certificate for best presentation at the meeting.



PETE NEIDIG, author of "Is Capital Really Tight in the Chemical Industry," is the immediate past president of Chemical Market Research Association. His is one of the truly unique careers in the profession; certainly few have gained such eminence by starting in chemical engineering and then forging a major portion of their careers in investment banking. As a partner of White, Weld & Co., Pete fills among his wide circle of acquaintances the obviously growing need for the specialist who can talk the language of finance as well as that of chemical engineering. His paper was the basis for the luncheon address given at the Los Angeles A.I.Ch.E. meeting.





The Mark of

Better Filtration

Tear a small piece from the continuous sheet of cake coming from a FEinc String Filter. Turn it over in your hand. In the closely spaced grooves you'll see why FEinc gives better filtration . . . on jobs ranging from thick fibrous cakes to thin sticky slimes.

The strings literally lift the cake out of the weave of the cloth. No scraper to wear, smear or plug the fabric. The cake is dryer, too. Cleaner cloth aids filtrate removal, with less vacuum. No "blow-back" is needed to loosen the cake, hence no filtrate is blown back into the cake. If FEinc's Compression

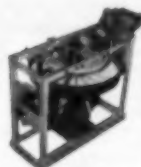
Dewatering Mechanism is added, you get 2 to 6% more moisture out of the cake.

It all adds up to higher yield with FEinc: Cleaner, more workable cake . . . higher recovery of solubles . . . higher filtration rates with a smaller filter . . . extra savings in reduced "down-time" and longer cloth life.

The Original String Discharge Filter is now only one of many types of FEinc continuous rotary vacuum filters available . . . custom-made at standard costs. Write for bulletins today, or ask for performance studies. No obligation, of course.



STRING



HORIZONTAL



SCRAPER

CUSTOM DESIGNED CONTINUOUS FILTRATION

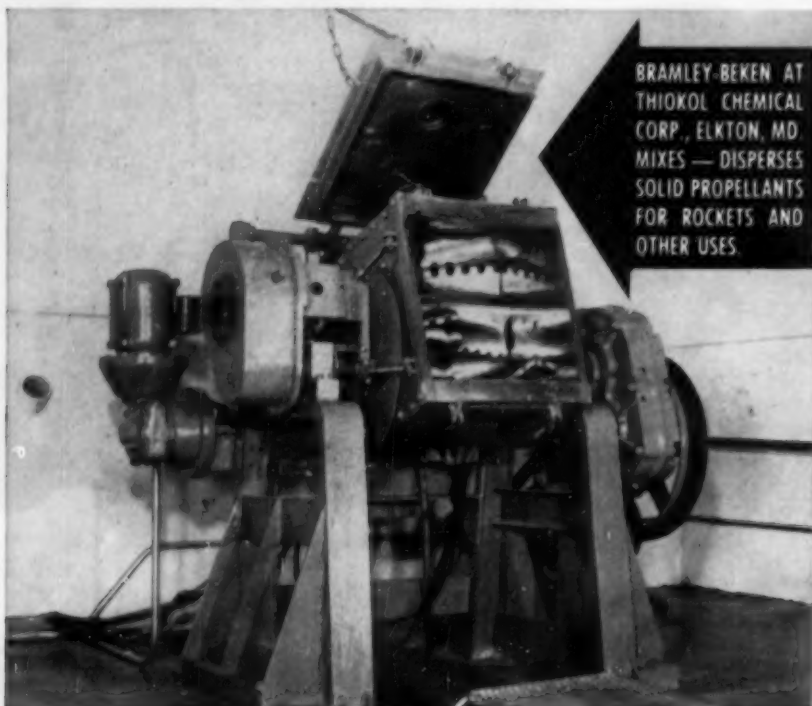
FEinc

*For a
Bigger Yield*

FILTRATION ENGINEERS, INC.

155 Oraton Street, Newark 4, N. J.

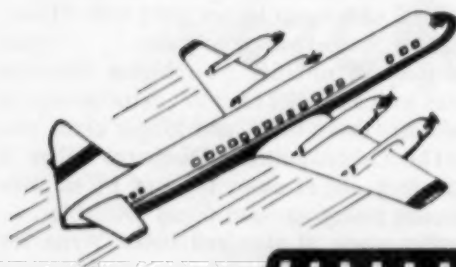
Now BRAMLEY-BEKEN SELECTED BY *Thiokol*.



BRAMLEY-BEKEN AT
THIOKOL CHEMICAL
CORP., ELKTON, MD.
MIXES — DISPERSES
SOLID PROPELLANTS
FOR ROCKETS AND
OTHER USES.



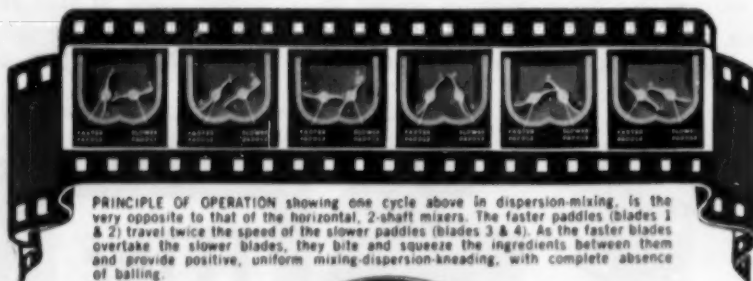
Because... **VERY EFFICIENT** for MIXING SOLID PROPELLANTS for ROCKETS and
OTHER USES *Where* **DEPENDABILITY IS A Must!**



HEAT TRANSFER IS DIRECT AND POSITIVE. Paddles draw material away from the trough walls instead of building up heat by pushing or smearing against the walls. |
ALL POWER GOES INTO PRODUCTIVE WORK. Only that part of the mass being squeezed between the multiple paddle blades is worked on at any one time. Hence, saving in power ... increased productivity ... less operating and maintenance costs ... faster output ... and a better end-product.

Laboratory and pilot test facilities are available.

The selection of the Bramley-Beken by America's top leaders in the chemical and processing industries is significant and indicative.



PRINCIPLE OF OPERATION showing one cycle above in dispersion-mixing, is the very opposite to that of the horizontal, 2-shaft mixers. The faster paddles (blades 1 & 2) travel twice the speed of the slower paddles (blades 3 & 4). As the faster blades overtake the slower blades, they bite and squeeze the ingredients between them and provide positive, uniform mixing-dispersion-kneading, with complete absence of balling.



880c RIVER ROAD

EDGEWATER, N. J.

Buyers of Any Process Equipment
Reap Benefits from M. W. Kellogg's

COMMITTEE WORK

ANOTHER PLUS IN KELLOGG'S
**BUILT-IN
ENGINEER**

As a leader in the design and fabrication of petroleum and petrochemical process equipment, The M. W. Kellogg Company assumes many extra curricular responsibilities which eventually benefit not only its customers but the process industries in general. One of these responsibilities is Kellogg's participation in technical committees of professional societies and associations, particularly at subcommittee working levels.

At present, M. W. Kellogg's engineers, metallurgists and others give a considerable part of their time to over seventy such activities . . . ranging from boiler and pressure piping codes to welding practices and radiographic testing techniques. Many of today's accepted design concepts were in-

troduced to the engineering profession by Kellogg committee men.

The M. W. Kellogg Company is privileged to contribute increasingly to the important work of technical and engineering societies, associations, and related groups. The practical application of the knowledge imparted and gained is another plus which goes into Kellogg's "built-in engineer" approach to process equipment design and fabrication. A typical example is a paper prepared by M. W. Kellogg engineers, "Collection and Correlation of High Temperature Hydrogen Sulfide Corrosion Data," and presented at a recent meeting of the National Association of Corrosion Engineers. *Write for your copy.*

Fabricated Products Division

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

*The Canadian Kellogg Company Limited, Toronto • Kellogg International Corporation, London • Societe Kellogg, Paris
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HEAT TRANSFER
EQUIPMENT



PROCESS
PIPING



KNOCKDOWN
VESSELS



TANKS AND
REACTORS



PRESSURE
VESSELS

| PERIODIC CLASSIFICATION OF THE ELEMENTS | | | | | | | | | | | | | | | | | | |
|---|----------------|-----------------|------------------|-----------------|----------------|-----------------|------------------|-------------------|----------------|-----------------|------------------|-----------------|----------------|-----------------|------------------|-------------------|----|----|
| GROUP | I _a | II _a | III _a | IV _a | V _a | VI _a | VII _a | VIII _a | I _b | II _b | III _b | IV _b | V _b | VI _b | VII _b | VIII _b | | |
| PERIODS | 1 | H | | | | | | | | | | | | | | | | He |
| | 2 | Li | Be | | | | | | | | | | | | | | | Ne |
| | 3 | Na | Mg | | | | | | | | | | | | | | | Ar |
| | 4 | K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br |
| | 5 | Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I |
| | 6 | Cs | Ba | La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At |
| | 7 | Fr | Ra | Ac | Rare Earths | | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm |
| | | | | Ac Series | | | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | | | |

Lithium, by reason of its atomic configuration and general characteristics, is rightfully included as the first member of Group I in the Periodic Table. A detailed study of the properties and reactions of both the elements and their compounds, however, shows that Lithium often resembles the metals of Groups II and III more closely than Group I. Following are some characteristic differences:

Lithium differs in organic chemistry . . .

because its organolithium compounds form a unique class with stability, solubility and activity characteristics intermediate between those of the Group I and Group II organometallic compounds.

Lithium also differs from the other alkali metals in that it serves as a unique catalyst for the polymerization of diolefins to materials of definite and predictable structure. It directs, for example, the polymerization of isoprene predom-

inantly to 1,4 addition structures.

Again, recent investigations have indicated an interesting potential as a direct reducing agent in solvents such as ammonia, low molecular weight amines, and ethylenediamine.

Lithium differs in metallurgy...

inasmuch as the affinity of Lithium for oxygen, for example, is being utilized to reduce porosity in copper and copper alloy castings. Recent research has revealed that Lithium will produce brazing alloys with self-fluxing properties and increase the wetting ability of these alloys.

Lithium differs in inorganic chemistry . . .

the usefulness of Lithium Hydride and Lithium Aluminum Hydride in the preparation of other hydrides having already been widely demonstrated. Recent studies indicate that other complex hydrides prepared in a similar manner may

prove to be interesting tools for research. The low dissociation pressure of Lithium Hydride at its melting point, to cite a specific example, is unique among all hydrides. LiH also has some slight solubility in polar organic compounds which is again unique among alkali metals.

Lithium differs in heat transfer . . .

based on its physical properties it has no equal as a liquid metal coolant. Due to corrosion caused at elevated temperatures by impurities in commercially available Lithium and Lithium Metal, Lithium has thus far found only experimental use.

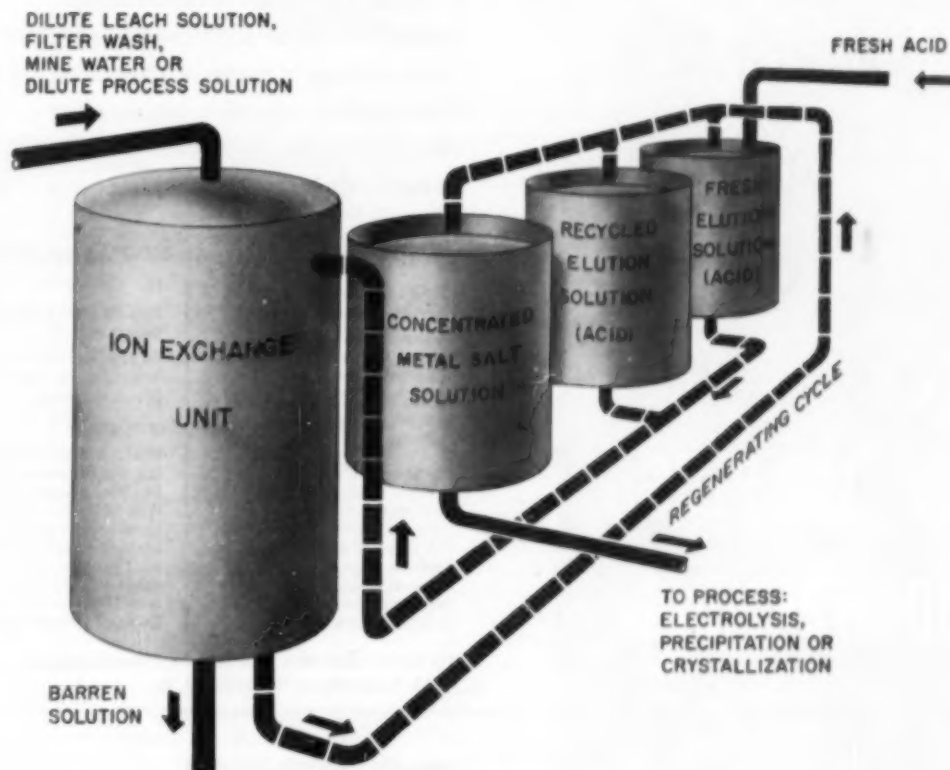
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| Aluminum | | Rare Earths |
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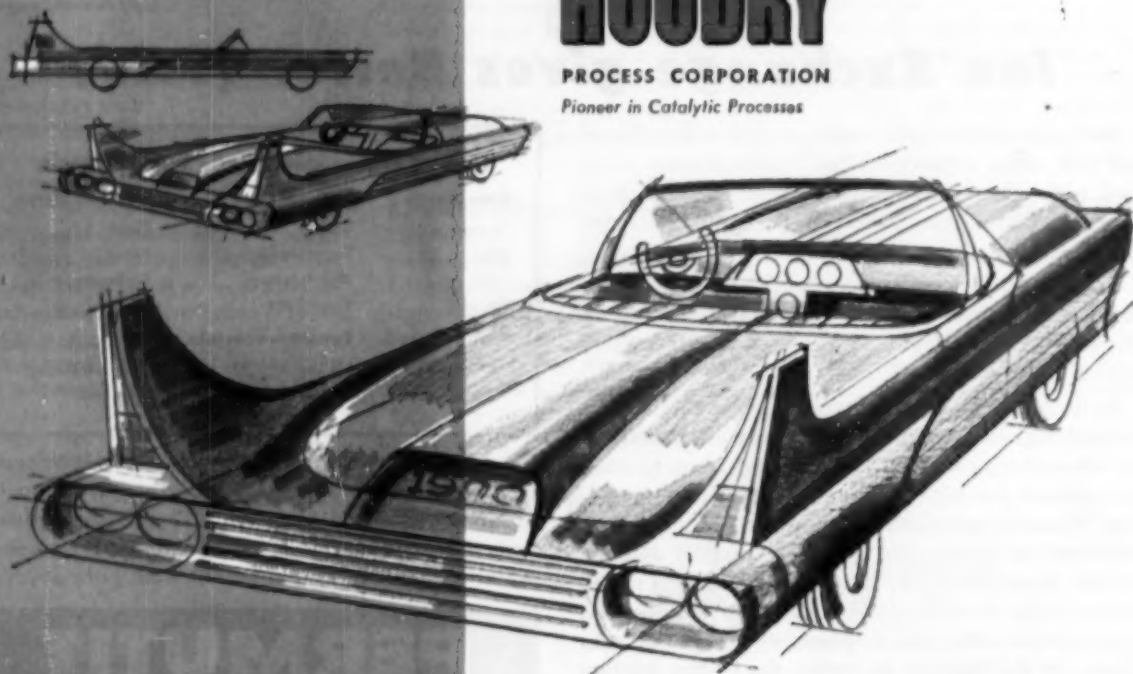
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Plastics are continuing their expansion as dramatically as in the past, spurred by new and unexpected applications, new techniques, the opening of new fields and the development of new materials. Barring temporary setbacks in one area or another, there seems little reason to look for anything but new high records in production and sales over the next few years.

The industry is prognosticating a volume of around 4 billion pounds this year against 3,500,000,000 pounds in 1955, and roughly 5 times the volume of 800 million pounds ten years ago. There are many hopeful guesses on the total volume the industry might reach by 1960. A continuation of the present rate of growth could bring a total volume of 6 billion pounds by 1960. It is difficult, however, to tell what increases will be registered by the older plastics and impossible to tell what gains may be scored by some of the newer materials and combinations of materials in fields which at the moment may not be thought of.

Major Developments

Several major pieces of news this year have plastics people vitally interested and should have an important impact on the industry in the next few years. One is the advent of the Ziegler and Phillips Petroleum low-pressure catalytic processes for making polyethylene with properties differing from those of the high pressure variety. It seems indicated that this provides another new plastic, and not just a competitor to the present polyethylene now selling at the rate of about 500 million pounds yearly.

Apparently these low-pressure processes can also be turned to other chemical uses, including the possibility of other varieties of plastics.

The announcement by Union Carbide & Carbon Corp. of a new, low cost method for making peracetic acid may also have an important impact on the plastics field, as well as on the chemical industry generally.

The third striking piece of news is the Italian Montecatini process for making polypropylene as well as polystyrene and polybutadiene by catalytic methods.

New Applications

Ingenuity on the plastics front is not confined to the development of new materials and new processes. A number of interesting combinations of materials were unveiled at the recent plastics show in New York which may open nearly as many new and extended fields as entirely new plastics. One of these materials is a styrene sheet surfaced with Mylar which withstands corrosion and heat. This might find use as compartments for storing foods in stores. It

also has excellent electrical properties, but it is so new that uses have not been fully evaluated.

Another new product with interesting possibilities is a structural material made of styrene foam surfaced on one side with fiber glass and on the other side with high-impact styrene. It is already being used in refrigerators and may have uses in the building field.

Plastics people, especially makers of urea, are looking forward to color television partly for the reason that they feel that color TV will create a large demand for colored plastic set housings.

At the plastics show also, polymers of styrene, acrylonitrile, and other styrene plastics were shown which have improved resistance to corrosion and heat, and although they may not be the final answer for some applications, they will extend the styrene field.

Although styrene is one of the older plastics and has been facing competition from other materials, it has held its ground and made excellent gains. Many in the industry feel that this material has far from exhausted its possibilities. The new use of styrene foams is one example. Further on the horizon are thin-wall, disposable drinking cups which have an advantage over paper for beverages and could run into substantial volume.

Optimists in the field are now taking a look at the cigarette container market. They note that brands packaged in stiff cardboard containers seem to be gaining ground, and that it might be possible to make thin, stiff disposable packages of styrene. If this works, another substantial market would be opened. It also points the way toward other large markets in the container field.

Plastics in Homes

There is also a drive under way, just beginning to gain momentum, to extend the application of plastics in the home building field. Although already widely used, plastics seem to have even more impressive opportunities, especially in view of the trends in modern housing. Plastic tiles for bathrooms and kitchens are still far from having reached a peak. The use of polyethylene sheets as moisture barriers and as temporary enclosures for buildings under construction is just beginning to be accepted, and plastic foam insulation, soft foams for upholstery, sliding panels, and doors are all large potential markets.

Plastics are also growing rapidly in use in the furniture industry, with whole bureau drawers, for example, being molded in one piece. These have the advantages of being dimensionally stable and therefore non-sticking. Efforts are also being made to push plastics in the "do-it-yourself" field for the home-making of furniture.



Recommended Reading for

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Great Interest Was Evidenced

If one can judge from the interest evidenced in the recent symposium on technical writing at the New Orleans A.I.Ch.E. Meeting, it would seem that this is a subject of prime importance to the chemical engineer. A tabulation of the attendance at the symposium estimated as present about everyone not otherwise occupied by plant trips or the day-long session of the Local Sections Activities Committee. Apparently it is true in this field as in many others today: a great many people are interested in self-improvement measures.

No quick and easy formula was promised by the teachers present. While certain rules should be followed because they represent general truisms, no particular text or reference work was cited as having all the answers. Instead, it was felt that so much depends on the individual's own set of problems.

Many of the general rules applicable to reports, as discussed by the industrial research executive present on the panel, covered such elements as purpose, contribution, conciseness, suitability, and timeliness. Certainly these apply to all technical writing. But just how does one go about doing all this? How does one synthesize the right combination of words, sentences, and paragraphs to a suitable form?

Working with a competent teacher, either privately or in a class, and development of a critical sense toward one's own writing as well as that of accomplished authors, will help. Then too, there was agreed to be no substitute for writing, writing, writing.

Another aspect of the problem of writing as it affects contemporary chemical engineering literature was raised: this was the question of the responsibility of those possessing specialized knowledge which could be transmitted to other members of the profession for the benefit of all concerned. All panel members agreed that the person with a good grasp of his subject usually writes with greater ease and better results as long as he stays with such subject material. On his specialty, he may be a lucid writer, and with relatively little effort. On other subjects, with which he has less familiarity, he may find the job of turning out comparable written material much more difficult.

For such people—those who have important information to share—it is important that no serious impediments stand in the way of their passing along knowledge to those who need it. The danger of rejecting such valuable information for the reasons that it is not written in the style or length desired is a problem that faces every editor. More and more, periodicals serving the fields of engineering and science are having to cope with this problem—one which deserves serious consideration. In the case of C.E.P., we are also concerned about this in connection with our program of expanding the publication of material relating to applied phases of chemical engineering. In doing this, we are attempting to render counsel and even direct aid to the author who for personal reasons finds it impossible to write his very important information in the particular style or length which are practical for magazine publication. A program such as ours is intended to assure publication of important information, not to offer aid where it is not needed.

Certainly, it is a part of a truly professional attitude to share responsibility for maintaining a vital progressive literature. Likewise it is a publication's responsibility to be selective, and to present its material in most readable, interesting form.

J.B.M.



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The purpose of the investigation described herewith was to determine the comparative performance and pressure drop characteristics of representative cooling-tower packings similar to those in common use in industrial cooling towers. These packings consist, in general, of bars or grids fabricated from redwood lumber, spaced relatively far apart both horizontally and vertically so that the percentage of voids in the cooling tower is usually in excess of 97 per cent. The data presented are shown to be in agreement with field tests on commercial cooling towers.

comparative performance of COOLING TOWER PACKING ARRANGEMENTS

Neil W. Kelly and Leonard K. Swenson | J. F. Pritchard & Company, Kansas City, Missouri

Despite the present widespread and continually growing use of cooling towers for heat dissipation in power and process plants, comparatively little information is available on the specific performance and pressure drop characteristics of the types of cooling-tower packing arrangements in current use. Some basic data, not directly applicable to the splash-grid packings currently in use in large industrial cooling towers, are available on the subject of heat and mass transfer between water and air in spray towers (8), wetted-wall columns (13), and small columns packed with relatively dense film-type packings (6, 10, 12).

Theory and Review

The basic equations covering combined mass and heat transfer phenomena have been covered in the literature (9). Likewise, the simplification, made possible for the system water-air by the fortuitous circumstance that the Lewis modulus, h/kc_a , is approximately unity, has been covered (7). Resulting equations for the combined heat and mass transfer in the system water-air involve an over-all mass transfer coefficient, K , together with a driving force that is the air enthalpy.

$$G di_G = Ka(i_L - i_G) dV \quad (1)$$

From a heat balance,

$$G di_G = Lc_p dt_L + c_p dL(t_L - t_w) \quad (2)$$

If the second term on the right side of Equation (2) can be ignored, and L assumed constant,

$$G di_G = Lc_p dt_L \quad (\text{nearly}) \quad (3)$$

Equation (1) becomes, by substitution of Equation (3),

$$Lc_p dt_L = Ka(i_L - i_G) dV \quad (4)$$

Solving Equation (4) and integrating, with $c_p = 1.0$ for water,

$$\frac{KaV}{L} = \int_{i_1}^{i_2} \frac{dt_L}{i_L - i_G} \quad (5)$$

Solving Equation (1) and integrating,

$$\frac{KaV}{G} = \int_{i_1}^{i_2} \frac{di_G}{i_L - i_G} \quad (6)$$

The dimensionless left side of Equation (6) has been named "number of transfer units" after Colburn (4). The left side of Equation (5) has been defined as the "tower characteristic" after Lichtenstein (5).

Despite the fact that Equation (5) appears less accurate than Equation (6), the former equation, defining the "tower characteristic," has come into common use in the cooling-tower industry. Actually, the approximations inherent in (5) become of small concern compared to the approximations necessary to arrive at Equation (1) from which both Equations (5) and (6) are derived.

Lichtenstein has shown (5) that for a given cooling tower, a plot of KaV/L vs. the L/G ratio, with G as a parameter results in a closely spaced family of nearly parallel lines. Since, in commercial counterflow cooling-tower practice,

only a small over-all variation in G ranging from about 1,100 to 1,800 lb./ (hr.) (sq.ft.) would be considered for economic reasons, no great error results from correlating the data as plots of KaV/L vs. L/G . Data in the present investigation are presented in this manner (see Figure 2), and it will be seen that the tower characteristic is a function of L/G , and is not dependent on the specific value of G .

Test Facility

The cooling tower used in these studies consisted of a square column approximately 50 ft. high, having an inside plan area of 32.6 sq.ft. The column was double-sheathed, the inside sheathing consisting of redwood plywood and the outside of 9/16-in. redwood shiplap material. An air space was provided between the inside and outside sheathings and the tower was covered on the outside with 2-in. thick Styrofoam insulation to minimize heat losses. The air inlets for the tower were 3 ft. high by 5 ft., 8 in. wide openings located on two opposite sides of the tower just above the top of the 18-in. deep steel basin.

The air for the tower was provided by a squirrel-cage blower, in forced draft arrangement. Wet- and dry-bulb temperatures of the air entering the tower were automatically controlled by means of a steam injection system and an air heater coil located in the air duct at the fan discharge. Following humidification and heating, the air passed through a baffled mixing chamber and into a 30-ft. long straight run of 36-in. diam. duct equipped with an egg-crate straightener and an orifice plate. At the vena contracta of the orifice a pitot tube connected across a 2-in. inclined tube draft gauge gave a deflection which was calibrated by means of a twenty-point pitot-tube traverse upstream of the orifice plate

ORIGINAL EXPERIMENTAL DATA AVAILABLE

Twenty tables of detailed experimental data from which this article was written are available in limited quantity from the authors. These tables are also on file (Document 4869) with A.D.I. Auxiliary Publications Project, Library of Congress, Washington, D. C. These data are obtainable by remitting \$3.75 for photoprints and \$2.00 for microfilm.

to measure the total air flow. Approximately 15 ft. downstream from the orifice, the air duct branched into a Y, the arms of which were connected to the tower air inlets. Air wet- and dry-bulb temperatures were recorded and controlled to within 0.2° F. from calibrated-resistance thermometers located in the air duct approximately 5 ft. upstream of the Y.

The water system consisted of a pump taking suction from the cooling-tower basin and circulating the water through steam heaters, a calibrated quick-change orifice assembly and into the distribution system in the cooling tower. The hot water temperature was automatically controlled and recorded to within 0.2° F. with calibrated resistance thermometers with an air-operated controller and an air-operated valve in the condensate line of the water heaters. Make-up water was introduced into the system at the pump suction, downstream from the point at which the cold water temperature was measured and recorded by a calibrated resistance thermometer. The quantity of make-up water was automatically controlled from a float in the cooling tower basin and measured by a rotameter in the make-up water line. The orifice assembly for measuring the water circulation rate was connected to a 40-in. well-type mercury manometer. The water circulation rate was controlled by hand operation of a valve on the pump discharge.

The water distribution system in the cooling tower consisted of a 4-in. pipe main header with two 2-in. pipe cross-arms terminating in elbows into which the low-pressure splash-plate-type distributors were screwed. Each splash-plate was located in the center of an area approximately 3 feet square. The piping to the tower was arranged for locating the distribution system at any desired level at 6-ft. intervals to permit testing various packed heights.

The air pressure drop through the cooling-tower packed height was measured for each test point by means of static taps used in conjunction with a draft gauge. The bottom static tap was installed in the air inlet chamber just below the bottom fill deck; the top static tap was installed approximately 3 ft. below the top deck. Reported values of static pressure have been corrected by the ratio of the total number of decks installed to the number of decks between static taps, to give the pressure drop of the total packed section excluding distribution system. For the distribution system used, the air pressure drop was negligible.

Calibrated resistance thermometers in the air discharged from the tower re-

corded the outgoing air wet- and dry-bulb temperatures. All pertinent operating water and air temperatures were continuously recorded by resistance thermometers on a twelve-point electronic strip chart recorder to facilitate the determination of steady-state conditions. As a further check, precision mercury-in-glass thermometers were installed at all temperature measurement stations.

Experimental

Eight different cooling-tower decks were investigated. Two of these decks were run at two different vertical spacings. The pertinent dimensional data are given in Figure 1. All decks were constructed of rough redwood batts nailed to the edge of rough 1 × 2-in. redwood stringers. The decks were so constructed and arranged in the cooling tower that there was no open path from top to bottom of the tower which would permit water to fall through the packing without contacting decks.

The total height occupied by the decking was 20 ft., except for variable height studies in which the height was varied from 8 to 26 ft. For each deck, two values of air rate, G , substantially bracketing the limits of commercial application, were run. At each value of G four values of L were run. In all runs the hot water temperature was controlled to 120°. The wet bulb was controlled to 75° in all except one run in which a wet bulb of 70° was used. In addition to these runs, certain decks were selected to determine the effects of varying hot water temperature and inlet wet-bulb temperature. In all cases in this investigation, the exit air was found to be essentially saturated, with outgoing wet- and dry-bulb temperatures less than one degree apart.

For each test point the value of the tower characteristic, KaV/L , was calculated from Equation (5), by the use of a quadrature formula for numerical integration. Values of air enthalpy used were calculated for a total barometric pressure of 28.85 in. Hg, which was taken as the average barometric pressure at the cooling-tower site at 1,000-ft. elevation. Heat balance calculations were made for each test point by the use of Equation (2). The maximum deviation from a complete heat balance closure was found to be 9.6% with a mean deviation of 2.7% for the approximately 130 test points involved in this investigation.

Determination of End Effects

In the cooling tower as commonly constructed, the water is introduced at the top of the packed section through nozzles or distributors in such a way as to assure a relatively uniform distribution of water over the entire plan area of the packing. Air is introduced below the bottom of the packed section and flows upward through the packing countercurrent to the falling water. Mist extractors or drift eliminators located above the water distribution system reduce the quantity of liquid water carry-

over to a negligible amount to prevent excessive water loss and nuisance. Such a tower consists of three water-cooling sections in series: a plenum chamber below the packed section in which the incoming air is in contact with relatively large (5 to 6 mm.) drops of water falling from the packed section; the packed section; and the water distribution section. The magnitude of the end effects (bottom plenum and distribution sections) can be determined by selecting a particular deck arrangement and testing it at various packed heights with L and G held constant. A plot of KaV/L vs. number of decks will, upon extrapolation to zero height, give the value of KaV/L for the end effects at the test values of L and G .

The over-all tower characteristic can be expressed as the sum of the values of KaV/L for the end effects and for the packed section.

$$(KaV/L)_{\text{total}} = (KaV/L)_{\text{ends}} + (KaV/L)_{\text{packing}} \quad (7)$$

This procedure was used in variable height studies using Decks A and H. The experimental values for deck A are given in Figure 2, and cross-plotted in Figure 3. It will be noted that the tower characteristic of the end effects is of a small order of magnitude, averaging approximately 0.07 for decks A and H. Assuming that all other decks tested would have an equivalent end effect, the performance of all decks can be expressed as (see Equation (7))

$$\frac{KaV}{L} = 0.07 + AN(L/G)^{-n} \quad (8)$$

Equation (8) expresses the tower characteristic in terms of the number of decks, the water-to-air ratio, and the constants A and n . With the data from the present investigation, values of A and n have been calculated and are shown in Table 1.

From these values of A and n , the curve of KaV/L vs. L/G can be determined for any packed height for the decks tested. It should be noted that values for A and n are different for each deck and for different vertical spacings of the same deck.

A comparison between observed values of tower characteristic and values calculated from Equation (8) and Table 1 is given in Table 2. The mean deviation of the calculated from the observed values is 3.6%, with the maximum deviations occurring generally at the lowest values of water-to-air ratio.

Different types of water distribution systems may result in different values for end effects. The present investigation was for the purpose of determining the comparative performance of decks. For this reason, all tests were run with the same distribution system for which the end effects were essentially constant

and represented a small percentage of the total tower characteristic. Since the distribution system and lower plenum in the experimental tower are similar to those commonly found in industrial cooling towers, it is anticipated that end effects will occur in full-scale industrial towers.

Influence of Hot Water Temperature

The literature contains several reports (1, 8, 11) indicating that the tower characteristic or number of transfer units decreases as the hot water temperature increases. No really satisfactory explanation for this phenomenon has been given, and the literature shows considerable variation in the magnitude of the hot water temperature effect, ranging from no effect for a wetted wall column (13) to a substantial effect for a spray-filled tower (8). A series of runs was made in the present investigation with decks C, D, and I, in which the hot water temperature was varied from 100 to 150° F., at constant L , G , packed height, and wet-bulb temperature. The results, shown in Figure 4, indicate that the effect of hot water temperature is a function of deck geometry and spacing. In all three cases, the reduction of KaV/L , amounting on the average to only about 2% for each 10° change in hot water temperature, is substantially less than typical values reported in the literature for spray-filled and dense deck-filled cooling towers (1, 8).

Influence of Wet-Bulb Temperature

A series of tests was run with deck A to determine the effect of inlet wet-bulb temperature. The wet-bulb temperature was varied in 5° increments from 55 to 80°, at a constant relative humidity of 50%, holding L and G constant. The six values of KaV/L showed a maximum deviation from the average of 1.2% with no trend noted.

Air Pressure Drop

The filling, supports, and structural members of a cooling tower produce an air pressure drop proportional to their number and exposed area and approximately proportional to the square of the air rate. The water film flowing over the filling and structural parts of conventional designs reported in this paper is not of sufficient thickness to cause significant additional obstruction to the flow of air. Therefore, the pressure drop due to the water film on these parts may be considered independent of water rate.

The free falling water in the form of drops creates additional obstructions in proportion to the number of drops present. The number of drops present is proportional to the liquid loading L (see

Fig. 2. Tower characteristic, KaV/L , vs. water-to-air ratio for deck A at packed heights of 8, 14, 20, and 26 ft., with 120° F. hot water.

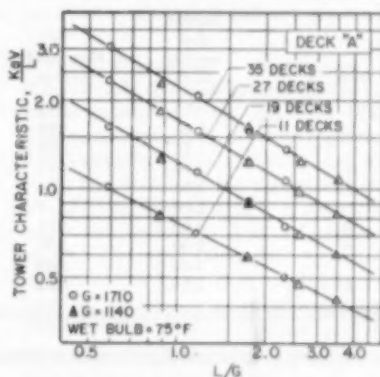
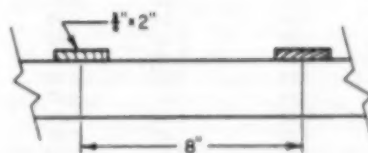


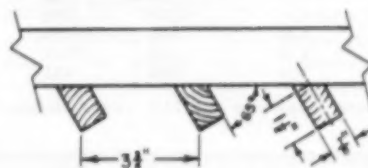
Fig. 1. Deck configurations tested. All supporting stringers shown are 1 × 2 in. with 2-in. dimension vertical. Deck E was tested with slope of grids in alternate layers reversed.

DECKS "A" & "B"



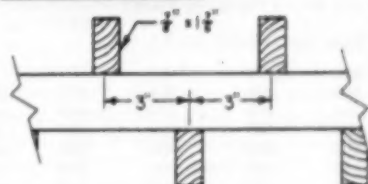
VERTICAL SPACING "A" = 9", "B" = 12"

DECK "E"



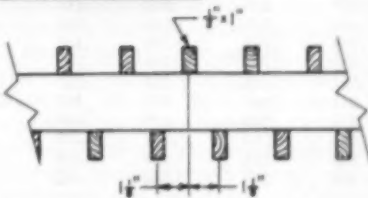
VERTICAL SPACING 24"

DECK "G"



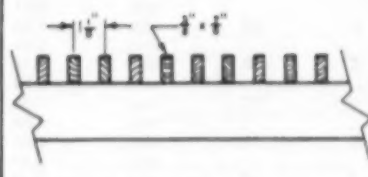
VERTICAL SPACING 24"

DECK "I"



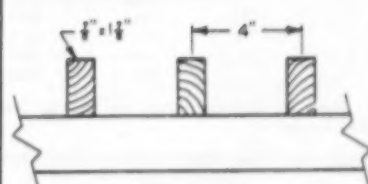
VERTICAL SPACING 24"

DECKS "C" & "D"



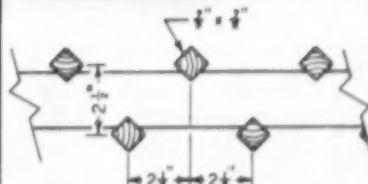
VERTICAL SPACING "C" = 15", "D" = 24"

DECK "F"



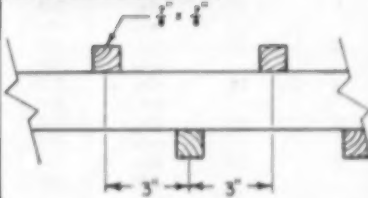
VERTICAL SPACING 24"

DECK "H"



VERTICAL SPACING 24"

DECK "J"



VERTICAL SPACING 24"

PERFORMANCE OF COOLING TOWER PACKINGS

Fig. 3. Cross-plot of Figure 2 showing small magnitude of end effects at zero decks.

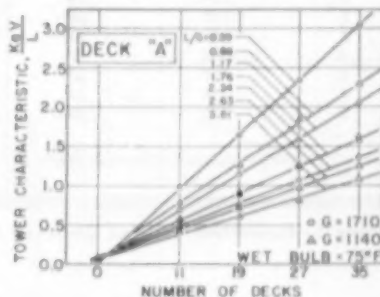


Table 1.—Values of A and n in Equation (8)

| Deck | A | n |
|------|------|-----|
| A | .060 | .62 |
| B | .070 | .62 |
| C | .092 | .60 |
| D | .119 | .58 |
| E | .110 | .46 |
| F | .100 | .51 |
| G | .104 | .57 |
| H | .127 | .47 |
| I | .135 | .57 |
| J | .103 | .54 |

Table 3.—Values of B and C in Equation (12)

| Deck | Vertical deck spacing, S, ft. | Plan solidity fraction, r | Vertical free fall S _v , ft. | B × 10 ² | C × 10 ¹⁸ |
|------|-------------------------------|---------------------------|---|---------------------|----------------------|
| A | .75 | .250 | 3.00 | .34 | .11 |
| B | 1.00 | .250 | 4.00 | .34 | .11 |
| C | 1.25 | .333 | 3.75 | .40 | .14 |
| D | 2.00 | .333 | 6.00 | .40 | .14 |
| E | 2.00 | .404 | 4.95 | .60 | .15 |
| F | 2.00 | .219 | 9.13 | .26 | .07 |
| G | 2.00 | .292 | 6.85 | .40 | .10 |
| H | 2.00 | .550 | 3.64 | .75 | .26 |
| I | 2.00 | .444 | 4.56 | .52 | .16 |
| J | 2.00 | .292 | 6.85 | .40 | .10 |

Table 2.—Comparison Between Observed Values of Tower Characteristic and Values Calculated from Equation (8) and Table 1.

| Deck | N | | Air rate G = 1,710 lb./hr.(sq.ft.) | | | | Air rate G = 1,140 lb./hr.(sq.ft.) | | | |
|------|----|-------|------------------------------------|-------|-------|-------|------------------------------------|-------|-------|-------|
| | | | Water rate L, lb./hr.(sq.ft.) | | | | Water rate L, lb./hr.(sq.ft.) | | | |
| | | | 1,000 | 2,000 | 3,000 | 4,000 | 1,000 | 2,000 | 3,000 | 4,000 |
| A | 27 | obs. | 2.35 | 1.58 | 1.24 | 1.07 | 1.84 | 1.23 | 0.97 | 0.82 |
| | | calc. | 2.31 | 1.53 | 1.21 | 1.02 | 1.82 | 1.21 | 0.96 | 0.81 |
| B | 20 | obs. | 1.84 | 1.32 | 1.05 | 0.91 | 1.66 | 1.11 | 0.83 | 0.70 |
| | | calc. | 2.01 | 1.34 | 1.05 | 0.90 | 1.58 | 1.08 | 0.84 | 0.73 |
| C | 17 | obs. | 2.18 | 1.59 | 1.23 | 1.06 | 1.67 | 1.21 | 0.92 | 0.78 |
| | | calc. | 2.22 | 1.49 | 1.19 | 1.01 | 1.76 | 1.19 | 0.95 | 0.81 |
| D | 11 | obs. | 1.76 | 1.35 | 1.06 | 0.89 | 1.42 | 1.04 | 0.80 | 0.68 |
| | | calc. | 1.86 | 1.26 | 1.01 | 0.87 | 1.48 | 1.01 | 0.82 | 0.70 |
| E | 11 | obs. | 1.62 | 1.22 | 1.00 | 0.90 | 1.34 | 1.02 | 0.84 | 0.74 |
| | | calc. | 1.63 | 1.20 | 1.01 | 0.89 | 1.36 | 1.01 | 0.85 | 0.75 |
| F | 11 | obs. | 1.48 | 1.11 | 0.86 | 0.72 | 1.23 | 0.94 | 0.73 | 0.55 |
| | | calc. | 1.51 | 1.09 | 0.90 | 0.79 | 1.25 | 0.90 | 0.75 | 0.66 |
| G | 11 | obs. | 1.52 | 1.16 | 0.94 | 0.80 | 1.27 | 0.93 | 0.76 | 0.61 |
| | | calc. | 1.62 | 1.12 | 0.90 | 0.78 | 1.30 | 0.90 | 0.73 | 0.63 |
| H | 11 | obs. | 1.81 | 1.31 | 1.11 | 0.98 | 1.56 | 1.14 | 0.97 | 0.85 |
| | | calc. | 1.87 | 1.37 | 1.15 | 1.02 | 1.56 | 1.15 | 0.96 | 0.85 |
| I | 11 | obs. | 2.00 | 1.47 | 1.17 | 0.96 | 1.62 | 1.20 | 0.93 | 0.82 |
| | | calc. | 2.11 | 1.44 | 1.16 | 1.00 | 1.69 | 1.16 | 0.93 | 0.81 |
| J | 11 | obs. | 1.45 | 1.18 | 0.95 | 0.81 | 1.26 | 0.92 | 0.74 | 0.62 |
| | | calc. | 1.63 | 1.14 | 0.84 | 0.81 | 1.29 | 0.91 | 0.74 | 0.65 |

Note: All observed values are for 120° hot water temperature and 20-ft. packed height. N is the number of decks required to make 20-ft. packed height.

Table 4.—Experimental Results of Air Pressure Loss and Values Calculated from Equation (12), in. Water

| | | Air rate G = 1,710 lb./hr.(sq.ft.) | | | | | | Air rate G = 1,140 lb./hr.(sq.ft.) | | | | | |
|------|----|------------------------------------|------|-------|-------|-------|-------|------------------------------------|-------|-------|-------|-------|--|
| | | Water rate L, lb./hr.(sq.ft.) | | | | | | Water rate L, lb./hr.(sq.ft.) | | | | | |
| Deck | N | | 0 | 1,000 | 2,000 | 3,000 | 4,000 | 0 | 1,000 | 2,000 | 3,000 | 4,000 | |
| A | 27 | obs. | .280 | .362 | .442 | .528 | .620 | .090 | .141 | .196 | .258 | .319 | |
| | | calc. | .270 | .354 | .438 | .522 | .606 | .119 | .181 | .243 | .305 | .367 | |
| B | 20 | obs. | .190 | .287 | .369 | .444 | .538 | .069 | .131 | .175 | .237 | .300 | |
| | | calc. | .200 | .285 | .370 | .455 | .540 | .088 | .153 | .218 | .283 | .348 | |
| C | 17 | obs. | .182 | .285 | .389 | .492 | .588 | .091 | .140 | .206 | .267 | .340 | |
| | | calc. | .199 | .285 | .371 | .457 | .543 | .088 | .153 | .218 | .283 | .348 | |
| D | 11 | obs. | .128 | .244 | .354 | .452 | .525 | .049 | .128 | .189 | .257 | .318 | |
| | | calc. | .129 | .227 | .325 | .423 | .521 | .057 | .134 | .211 | .288 | .365 | |
| E | 11 | obs. | .195 | .280 | .355 | .435 | .535 | .080 | .140 | .190 | .255 | .310 | |
| | | calc. | .193 | .275 | .357 | .439 | .521 | .086 | .149 | .212 | .275 | .338 | |
| F | 11 | obs. | .073 | .177 | .269 | .336 | .416 | .031 | .110 | .159 | .220 | .269 | |
| | | calc. | .084 | .162 | .240 | .318 | .396 | .037 | .101 | .165 | .229 | .293 | |
| G | 11 | obs. | .110 | .189 | .293 | .379 | .440 | .061 | .098 | .153 | .220 | .287 | |
| | | calc. | .129 | .208 | .287 | .366 | .445 | .057 | .120 | .183 | .246 | .309 | |
| H | 11 | obs. | .242 | .341 | .440 | .555 | .660 | .110 | .171 | .242 | .308 | .385 | |
| | | calc. | .241 | .341 | .441 | .541 | .641 | .107 | .182 | .257 | .332 | .407 | |
| I | 11 | obs. | .153 | .232 | .348 | .409 | .489 | .073 | .122 | .183 | .251 | .312 | |
| | | calc. | .167 | .245 | .323 | .401 | .479 | .074 | .134 | .194 | .254 | .314 | |
| J | 11 | obs. | .134 | .238 | .306 | .379 | .458 | .049 | .116 | .165 | .220 | .281 | |
| | | calc. | .129 | .208 | .287 | .366 | .445 | .057 | .120 | .183 | .246 | .309 | |

Note: All observed values are for 20-ft. packed height. N is the number of decks required to make 20-ft. packed height.

Figure 5), and to the time required for the water to fall through the tower. The pressure drop produced by the falling water is proportional to the square of the relative velocity ($v + v_p$) between the air flow, and the water drops falling by gravity.

The total pressure drop for the system is the sum of the pressure drops caused by the filling and support members and that resulting from the falling water drops.

In Fanning equation form:

$$\Delta P' = \frac{B' N \rho_a v^2}{2g} + \frac{6C' N \rho_a L \sqrt{2S_f/g} (v + v_p)^2}{2g 3600 D \rho_L} \quad (9)$$

The relative velocity term ($v + v_p$) for the falling water drops may be replaced by an equivalent uniform velocity v_B which, acting through the same distance S_f , produces the same amount of work on the air as that done by the falling drops. The work done by the falling drops is, in differential form,

$$dW = \frac{1}{2} \rho_a C_D A_F (v + v_p)^2 dS_f \quad (10a)$$

The work done in terms of v_B is

$$W = \frac{1}{2} \rho_a C_D A_F v_B^2 S_f \quad (10b)$$

On the assumption that the drag coefficient C_D is constant and that the water fall velocity v_p is not appreciably different from free fall velocity, gt , so that $S_f = \frac{1}{2} g t^2$, Equation (10a) can be integrated and combined with Equation (10b) to give

$$v_B = \sqrt{v^2 + 4/3v \sqrt{2gS_f} + gS_f} \quad (10c)$$

and

$$G_B = \sqrt{G^2 + 4/3G 3600 \rho_a \sqrt{2gS_f} + g(3600 \rho_a)^2 S_f} \quad (11)$$

Equation (11) is shown plotted as Figure 6.

Considerable convenience in correlation of test data is obtained by assuming that the probable height of free vertical fall, S_f , is proportional to the deck spacing, S , and inversely proportional to the plan solidity fraction, r , of the deck. With 0.0675 lb. dry air per cubic foot as an average density, the dimensionless constants B' and C' of Equation (9) can be combined with other constants to give the air pressure drop in inches of water per deck as functions of G , ρ_a , and L with new dimensional constants B and C for each deck design.

$$\frac{\Delta P}{N} = BG^2 \left(\frac{0.0675}{\rho_a} \right) + C \sqrt{S_f} LG^2 \left(\frac{0.0675}{\rho_a} \right) \quad (12)$$

With the use of the data from the present investigation, values of B and C have been calculated and are shown in Table 3.

Table 4 presents a comparison of pressure loss obtained by experiment and values calculated from Equation (12). The mean deviation between observed and calculated pressure drop for the forty test points at the higher air rate of 1,710 lb./hr. (sq.ft.) is 0.013 in. water and represents 3.5% of observed values. The mean deviation for the fifty test points at 1,140 lb./hr. (sq.ft.) is 0.020 in. water with the calculated values generally higher than the observed values. It should be noted that the test results have not been corrected for the difference in density within the test cell and the manometer lines. This difference would produce small but measurable corrections to be added to the observed pressure drop, especially at the lower air rate.

Deck A is identical to deck B, and deck C is identical to deck D except for vertical spacing in the tower. As is indicated in Table 3, the values of B and C are constant in Equation (12) for each deck construction, regardless of vertical spacing; these values correlate the pressure drop for variation of deck vertical spacing, water rate, air rate, and number of decks. The constant B is determined by the geometry and horizontal spacing of the grids for each deck design. The constant C is a function of splash pattern and drop diameters produced. The influence of grid geometry on B and C is a subject of continuing study.

Correlation with Field Test Data

Field tests on large industrial cooling towers are difficult to obtain with the degree of accuracy that can be obtained in an experimental tower. The wet-bulb temperature of the air entering the tower varies from moment to moment and from place to place around the tower due to the variable condition of the atmosphere and to recirculation of discharge vapors from the tower itself. It is, therefore, difficult, in most cases, to determine the average wet-bulb temperature of the air entering the tower. Likewise, obtaining air-flow and water-flow measurements with accuracy under field conditions frequently presents a problem.

Results of field tests on two commercial towers using Deck A are shown in Table 5. It will be noted that the measured tower characteristic, KaV/L , and measured static pressure drops are in good agreement with values calculated from tests reported in this paper.

The experimental tower used in this investigation has a plan area for air and

PERFORMANCE OF COOLING TOWER PACKINGS

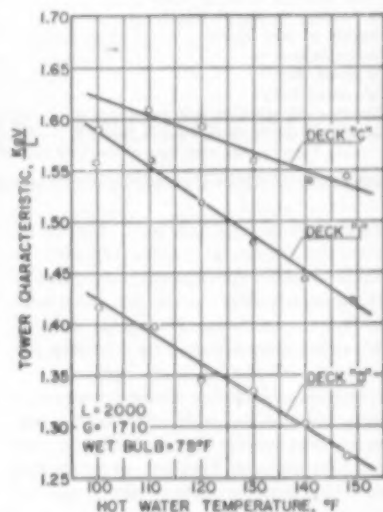


Fig. 4. Typical effect of hot water temperature on tower characteristic, KaV/L , at constant L , G , wet-bulb temperature, and packed height.

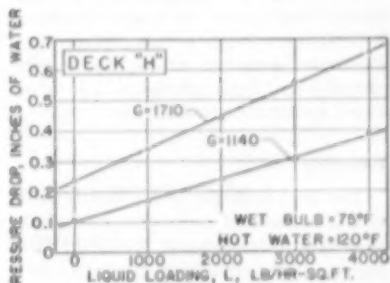


Fig. 5. Typical effect of liquid loading on air pressure drop, showing linear relationship.

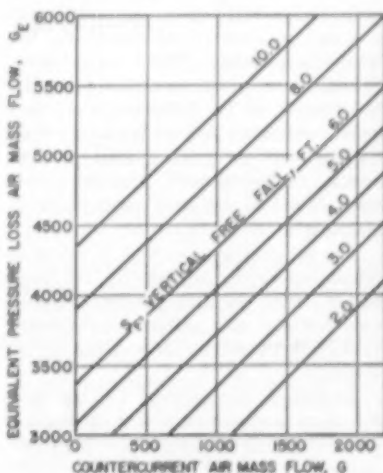


Fig. 6. Plot of Equation (11).

Table 5.—Comparison of Experimental Tower with Field Tower Tests, Using Deck A

| Tower number | 1 | 2 | 3 |
|---|----------------|----------------|----------------|
| Cell length \times width, ft. | 30 \times 42 | 36 \times 60 | 30 \times 48 |
| Hot water temperature, ° F. | 92.6 | 105.2 | 80.4 |
| Cold water temperature, ° F. | 78.0 | 88.5 | 70.7 |
| Inlet wet-bulb temperature, ° F. | 74.4 | 64.8 | 50.2 |
| Water loading, L , lb./hr.(sq.ft.) | 1,104 | 1,296 | 2,250 |
| Air loading, G , lb./hr.(sq.ft.) | 1,370 | 474(1) | 1,070 |
| Number of deck layers | 35 | 43 | 35 |
| Packed height, ft. | 26 | 32 | 26 |
| Observed KaV/L | 2.66 | 1.53 | 1.33 |
| Calculated KaV/L | 2.56 | 1.46 | 1.39 |
| Observed air pressure loss, in. water | 0.312 | 0.100 | 0.293 |
| Calculated air pressure loss, in. water | 0.326 | 0.118 | 0.311 |

(1) Tower tested with fans at one-half normal speed.

water flow of only 32.6 sq.ft. Compared with the industrial towers reported in Table 5, the experimental tower has a disproportionately large ratio of wall surface to plan area. The inside walls of the experimental tower had devices for stripping off the water and returning it to the tower packing. These devices may have reduced the wall effect in the experimental tower, thereby effecting the good agreement between experimental and field tests in spite of the large difference in size of equipment.

The total air pressure drop through a cooling tower is the sum of the pressure drop through the air inlet louvers, the packed height, and the drift eliminators. Information from which louver and eliminator pressure losses may be predicted from their geometry are to be found in the literature (2, 3).

Summary

The heat transfer and pressure drop characteristics of representative splash-grid type cooling-tower packings have been reported from tests conducted in a six-foot square experimental counterflow tower. The factors influencing the value of the tower characteristic, KaV/L , were found to be the water-to-air ratio, the packed height, the deck geometry and, to a very small extent, the hot water temperature. The tower characteristic at a given water-to-air ratio, was found to be independent of wet bulb temperature and air loading, within the limits of air loading used in commercial cooling towers. The end effects were found to be of a small order of magnitude.

The air pressure loss was found to be influenced by the air velocity, the number of decks, the deck geometry, the liquid loading, and a theoretical relative velocity between the air and the falling water.

Simplified expressions for the performance and pressure drop characteristics of the decks tested have been presented as a starting point for generalized correlations covering all types of com-

mmercial counterflow and crossflow high voidage cooling-tower packings.

Field tests were found to correlate reasonably well with the experimental tower results. The correlations presented can be expected, therefore, to predict performance of field cooling towers with reasonable accuracy.

Acknowledgment

The authors wish to thank J. F. Pritchard & Company for permission to publish this paper; C. P. Springstube, who assisted in the calculations; and L. D. Hamlin and D. C. Wilson, who operated the experimental equipment and obtained the field test data.

Notation

- A = constant in Equation (8)
- A_F = frontal (plan) area of falling water drops, sq.ft.
- a = area of transfer surface per unit of tower volume, sq.ft./cu.ft.
- B, C = constants in Equation (12), dimensional
- B', C' = constants in Equation (9), dimensionless
- C_D = drag coefficient for falling water drops, dimensionless
- c_p = specific heat of liquid water, B.t.u./lb.(° F.)
- c_a = humid heat of air, B.t.u./lb.(° F.)
- D = mean water drop diameter, ft.

Literature Cited

- Baker, D. R., and L. Y. Mart, *Refrig. Eng.*, **60**, 965-971 (1952).
- Bevier, C. W., *Heating, Piping Air Conditioning*, **27**, 159-164 (1955).
- Chilton, H., *Trans. Inst. Chem. Engrs. (British)*, **30**, 235-250 (1952).
- Colburn, A. P., *Trans. Am. Inst. Chem. Engrs.*, **35**, 212 (1939).
- Lichtenstein, J., *Trans. Am. Soc. Mech. Engrs.*, **65**, 779-787 (1943).
- London, A. M., W. E. Mason, and I. M. K. Boelter, *Trans. Am. Soc. Mech. Engrs.*, **62**, 41-50 (1940).
- McAdams, W. H., "Heat Transmission," 3 ed., McGraw-Hill Book Company, New York, 356-365 (1954).
- Niederman, H. H., et al, *Heating, Piping Air Conditioning*, **13**, 591-597 (1941).
- Sherwood, T. K., and R. L. Pigford, "Absorption and Extraction," 2 ed., McGraw-Hill Book Company, New York, 102-104 (1952).
- Simpson, W. M., and T. K. Sherwood, *Refrig. Eng.*, **52**, 535-543 (1946).
- Snyder, N. W., Paper presented at Louisville, Kentucky, before Am. Inst. Chem. Engrs. (March 20-23, 1953).
- Spurlock, B. H., *Heating, Piping Air Conditioning*, **25**, 115-121 (1953).
- Stancifft, R. J., Ph.D. Thesis, University of Kansas (1951).

- G = air mass velocity, lb. dry air/(hr.)(sq. ft. of plan area)
- G_E = equivalent mass air velocity for pressure drop between air and falling water drops, lb./hr.(sq.ft. of plan area)
- g = gravitational constant, 32.16 ft./sec. (sec.)
- h = heat transfer coefficient, B.t.u./hr.(sq.ft.)(° F.)
- i_a = enthalpy of air saturated at wet-bulb temperature, B.t.u./lb. dry air
- i_L = enthalpy of air saturated at bulk water temperature, B.t.u./lb. dry air
- K = over-all enthalpy transfer coefficient, lb./hr.(sq.ft. transfer area) (lb. water/lb. dry air)
- k = mass transfer coefficient, lb./hr.(sq. ft. transfer area) (lb. water/lb. dry air)
- L = water mass velocity, lb./hr.(sq.ft. of plan area)
- N = number of deck levels in tower
- n = exponent for water-to-air ratio in Equation (8)
- $\Delta P'$ = air pressure loss, lb./sq.ft.
- ΔP = air pressure loss, inches of water
- r = deck plan solidity fraction
- S = vertical spacing of decks, ft.
- S_F = vertical free fall of water drops, ft. (= S/r)
- t_0 = base temperature for water in calculation of air enthalpy, ° F. (= 32° F.)
- t_1 = water temperature at bottom of tower, ° F.
- t_2 = water temperature at top of tower, ° F.
- t_L = water temperature of bulk water, ° F.
- v = air velocity, ft./sec.
- v_E = integrated mean velocity between air and falling water drops, ft./sec.
- v_F = mean free fall velocity of water drops, ft./sec.
- V = tower volume, cu.ft./sq.ft. plan area
- W = work done on air by falling water, ft.-lb.

GREEK LETTERS

- ρ_L = density of liquid water, lb./cu.ft.
- ρ_a = density of air, lb. dry air/cu.ft. of mixture

IS CAPITAL REALLY TIGHT IN THE PROCESS INDUSTRIES?

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The question of the availability of investment capital in the chemical process industries depends first, on the nature of the project, and second, on the philosophy of the particular management regarding financing.

From the viewpoint of the investment banker, it may be said that capital can almost always be found for a soundly conceived project with a reasonable return on investment. But in answering the question in this way we are saying that if management is willing to use outside financing, then capital can be made available for good projects. Yet capital can be extremely tight for those companies which are completely dependent on internally generated funds, particularly if there are a number of good projects seeking those funds.

Internally Generated Capital

Among the various sources of capital, internally generated capital is, of course, of primary importance. It consists, in general, of depreciation and amortization plus retained earnings after payment of preferred and common dividends. Depreciation provides for the return investment over the expected useful lifetime of fixed assets. In the chemical industry, depreciation charges generally average around seven per cent a year on the total equipment investment, which suggests a useful life of approximately 15 years. During the Korean emergency, the Government granted Certificates of Necessity which provided for the amortization of a portion of the total cost over a five-year period, varying from about 45 to 90 per cent, dependent on how critical the project was to the Government. Under these Certificates of Necessity it was possible to recover the original capital much more rapidly than if only normal depreciation was used; thus industry was encouraged to expand. Under the new tax law passed in 1954 there are two

methods of figuring depreciation—sum-of-the-digits and declining balance—either of which is designed to permit more rapid recovery of capital than under the straight-line method. Although both these new methods of handling depreciation will show smaller reported earnings than the straight-line method, cash flow will be increased as a result of the tax savings. The heavier the capital expenditure program, the larger will be the depreciation charges.

The chemical industry has usually financed expansion out of its own funds except in times when abnormally high levels of capital expenditures are indicated. Thus, in the period immediately following World War II and again in the Korean emergency, most of the major chemical companies were forced to turn to outside capital to help finance their expansion.

Outside Capital

When a company looks for outside capital there are three types of securities which it can sell: common stocks, preferred stocks, or debt.

DEBT FINANCING

There are several reasons why many chemical companies have been using debt financing wherever possible. Interest on debt is a deductible expense before taxes, whereas dividends on preferred stock are paid from earnings available after taxes. The use of debt gives "leverage" to the common stock.

As an example, assume a chemical company is now earning \$1,000,000 and has 1,000,000 shares of common stock outstanding. This company has a new project which will require an investment of \$10,000,000 and will give a return of 20% on this investment before interest and taxes. The figures in Table I illustrate what happens to the earnings per share—which were initially \$1.00 a share—depending on which method of financing is used.

It is apparent that earnings are largest

Table 1.—Alternatives in Financing: Common Stocks, Preferred Stocks, and Debt

| | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|--|---|
| | Raise capital by selling common stock which is currently valued by the market at 10 times earnings or \$10 a share. | Raise capital by selling common stock which is currently valued by the market at 20 times earnings or \$20 a share. | Raise capital by selling 4% convertible preferred. Assume stock selling at 20 and must sell 100,000 shares of \$10 par preferred convertible into common at 23 or into 435,000 shares of common. | Raise capital by selling debt at 4% interest. |
| Operating Profit | \$2,000,000 | \$2,000,000 | \$2,000,000 | \$2,000,000 |
| (from new project) | | | | |
| Interest | — | — | — | 400,000 |
| Pre-Tax Earnings | \$2,000,000 | \$2,000,000 | \$2,000,000 | \$1,600,000 |
| Taxes at 50% | 1,000,000 | 1,000,000 | 1,000,000 | 800,000 |
| Balance | \$1,000,000 | \$1,000,000 | \$1,000,000 | \$ 800,000 |
| Present Earnings | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 |
| Total | \$2,000,000 | \$2,000,000 | \$2,000,000 | \$1,800,000 |
| Preferred Dividends | — | — | 400,000 | — |
| Balance | \$2,000,000 | \$2,000,000 | \$1,600,000 | \$1,800,000 |
| No. Common Shares Outstanding | 2,000,000 | 1,500,000 | 1,000,000 | 1,000,000 |
| Earnings a share | \$1.00 | \$1.33 | \$1.60 ¹ | \$1.80 |

¹ When the preferred stock is converted, the \$2,000,000 earnings would be equivalent to \$1.39 a share on the 1,435,000 shares outstanding.

on a per share basis if debt financing is used. They are smallest if common stock is sold, especially if the stock is valued at only ten times earnings by the market. In fact, under such conditions the earnings which were \$1.00 a share before the new project was undertaken are still \$1.00 a share after the new project. This illustrates how the market valuation of a company actually can affect its financing.

The higher the market appraises a company's earnings the less common stock need be sold to raise a definite amount of capital. The top chemical companies are currently being valued by the stock market at 20 to 25 times earnings. This relatively high price-to-earnings ratio compared with other industrial stocks reflects the outstanding growth records of chemical companies as well as the investors' expectation that future performances will be as good as the past ones. The price-earnings ratio reflects to a major degree the investors' understanding of a company's operations and the degree of confidence he has in the ability of the company and its management.

The principal objection to the use of debt financing is, of course, the fact that these borrowings must ultimately be repaid. In times of severe adversity, common and even preferred dividends do not have to be paid but a company can-

not fail to meet a debt obligation and still remain solvent.

The rate of return on investment of the proposed project is a very important factor in determining what kind of financing should be used. Thus, with a project soundly conceived from the standpoint of raw materials, potential markets, etc., which has a relatively low rate of return, it is desirable from the standpoint of the stockholders to use as much debt financing as possible. At the same time the element of risk is also an important point to consider—such considerations as the stability of the product and the industries it will serve; the likelihood of process obsolescence; and the possibilities of replacement by other products. Since debt must be repaid, the more risk there is in the project the more equity financing is indicated.

PREFERRED STOCKS

Straight preferred stocks are not widely used by chemical companies, the principal objection being the aforementioned tax consideration since preferred dividends are payable from earnings available after taxes. However, several chemical companies have raised capital by selling convertible preferred stocks.

From the company's viewpoint this type of issue is an excellent way of selling common stock at a premium. These preferreds are usually convertible into common stock at 10-20 per cent over the market at the time of issue for a period of 10 years.

In the example in Table 1, with the common stock selling at 20 the company had to sell 500,000 shares to raise the required \$10,000,000. The same amount of capital might also be raised by selling 100,000 shares of \$100 par preferred, convertible into common stock at 23. This would actually mean that 435,000 additional shares of common stock would ultimately be outstanding rather than the 500,000 shares, if common stock is sold. Thus by selling the convertible preferred the management raised its capital with less dilution to the common stockholder. These convertible preferred issues appeal to investors because they carry a fixed income rate and at the same time hold out the expectation of future capital gain.

COMMON STOCKS

Common stock is usually the most expensive form of outside financing for the company. It results in an increase in the number of shares of common stock outstanding, which usually means that earnings per share will decline somewhat until the new projects for which the financing was done are completed. On the other hand, sale of common stock is the most conservative way of raising capital since it does not carry any firm obligations as to the amount of dividends which must be paid.

Financing Methods Compared

The financing methods of several major process industries offer interesting comparisons. Table 2 shows the capital structures of the larger companies in the chemical, petroleum, and natural gas industries as of December 31, 1955.

Petroleum Companies

The capital structures of the petroleum companies closely resemble those of the chemical companies, although the petroleum companies generally have slightly lower percentages of debt. Cash available after dividends is substantially greater for petroleum companies than for most of the chemical companies, a reflection of the lower tax rate, due to the percentage depletion allowance. The oil companies require substantial quantities of capital to support their necessarily heavy drilling programs, but the degree of risk inherent in oil exploration makes it unwise to use debt capital for that purpose. It would seem quite realistic, however, to borrow money to finance expansion of refining facilities if additional capital is needed.

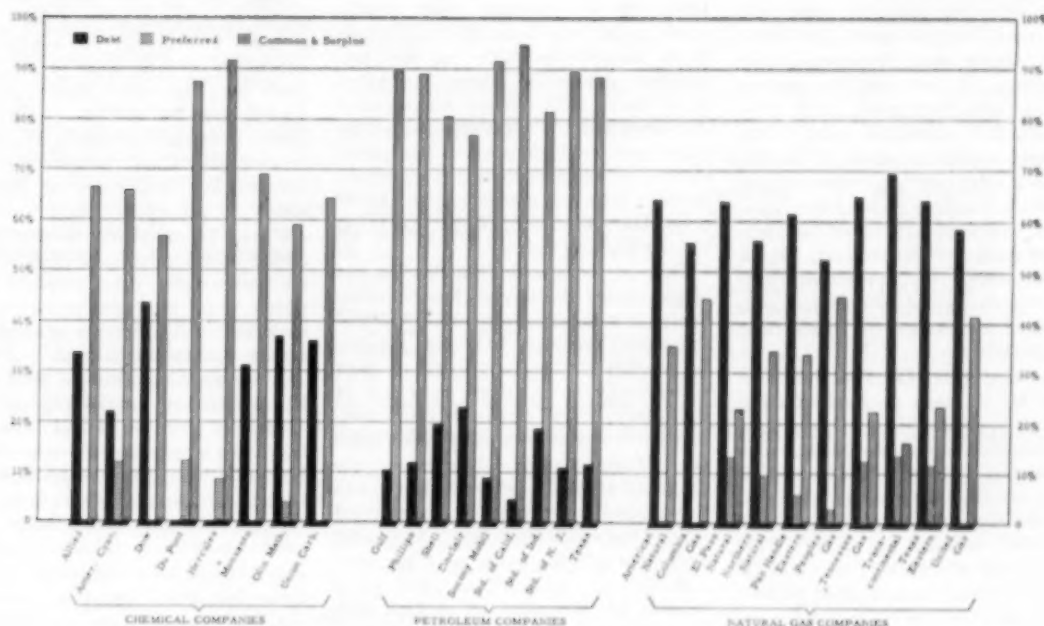


Chart showing capital structures of chemical, petroleum, and natural gas companies on a percentage basis.

Natural Gas Transmission Companies

The capital structures of the natural gas transmission companies are quite different from those of chemical and oil companies. Debt is relatively high, ranging upward to 75 per cent, but these companies can support a high debt because they are public utilities and as such are part of a regulated industry. Since amount of profit they can make is controlled by the Federal Power Commission, profit levels can be expected to be stable in good times and bad. Thus, the element of risk has been reduced and it is relatively easy to secure substantial debt financing. Suitable arrangements are usually made with future customers who contract to take enough of the gas on a firm basis to provide funds for the interest payments and sinking fund payments on the debt. The cash available after payment of common and preferred stock dividends and provision for sinking fund payments is relatively small compared with chemical companies since regulation keeps profits down; hence it is virtually impossible for a natural gas pipe line to embark on any major extension of its pipe line without resorting to outside financing. As might be expected, the financing of a gas pipe line is also tied directly to the life of the reserves.

Chemical Companies

Looking more closely at the major chemical companies, one finds wide differences in the handling of capital re-

Table 2.—Capital Structures of Chemical, Petroleum & Natural Gas Companies as of Dec. 31, 1955

| | Dollars (000,000) | | | |
|---------------------------------|-------------------|----------------|-------------------------------|-------------------|
| | Debt | Preferred | Common ¹ & Surplus | Total |
| CHEMICAL | | | | |
| Allied | \$ 200.0 | — | \$ 403.3 | \$ 603.3 |
| American Cyanamid | 94.8 | \$ 50.4 | 279.4 | 424.6 |
| Dow (Fiscal Yr. May 31, 1955) | 242.0 | — | 316.4 | 558.4 |
| du Pont | — | 238.9 | 1,732.1 | 1,971.0 |
| Hercules | — | 8.7 | 91.5 | 100.2 |
| Monsanto | 154.5 | — | 344.7 | 499.2 |
| Olin Mathieson | 199.6 | 21.9 | 321.7 | 543.2 |
| Union Carbide | 410.0 | — | 732.9 | 1,142.9 |
| Total | \$1,300.9 | \$319.9 | \$ 4,222.0 | \$ 5,842.8 |
| PETROLEUM | | | | |
| Gulf | \$ 175.5 | — | \$ 1,528.5 | \$ 1,704.0 |
| Phillips | 118.9 | — | 901.1 | 1,020.0 |
| Shell | 201.5 | — | 814.9 | 1,016.4 |
| Sinclair | 248.7 | — | 829.0 | 1,077.7 |
| Socony Mobil | 181.0 | — | 1,845.1 | 2,026.1 |
| Stand. Oil Calif. | 78.6 | — | 1,527.2 | 1,605.8 |
| Stand. Oil Ind. | 391.2 | — | 1,701.1 | 2,092.3 |
| Stand. Oil N. J. | 557.9 | — | 4,680.2 | 5,238.1 |
| Texas | 209.0 | — | 1,676.7 | 1,885.7 |
| Total | \$2,162.3 | — | \$15,503.8 | \$17,666.1 |
| NATURAL GAS | | | | |
| American Natural ² | \$ 299.6 | \$ 0.8 | \$ 162.8 | \$ 463.2 |
| Columbia Gas ² | 330.0 | — | 263.3 | 593.3 |
| El Paso Natural ² | 365.1 | 76.4 | 128.6 | 570.1 |
| Northern Natural ² | 177.5 | 29.6 | 108.4 ⁴ | 315.5 |
| Pan Handle Eastern ² | 133.1 | 12.1 | 71.9 | 217.1 |
| Peoples Gas ² | 222.6 | 11.5 | 191.2 ⁴ | 425.3 |
| Tennessee Gas ² | 499.8 | 97.6 | 166.4 | 763.8 |
| Transcontinental ² | 215.4 | 42.5 | 90.7 | 308.6 |
| Texas Eastern ² | 294.9 | 55.2 | 105.3 ⁴ | 455.4 |
| United Gas ² | 335.3 | — | 238.5 ⁴ | 573.8 |
| Total | \$2,873.3 | \$325.7 | \$ 1,487.1 | \$ 4,686.1 |

¹ Book value. ² Integrated companies. ³ Transmission companies. ⁴ Includes minority interest.

quirements. The absence of any long-term debt on the Du Pont balance sheet might suggest that it is unnecessary to use debt financing since the company's growth record has been good. The Union Carbide balance sheet, however, shows \$410 million of debt and its growth record has also been good. And Dow Chemical's debt represents nearly 44% of its total capitalization in 1955. Du Pont has a relatively large issue of preferred stock (without sinking fund provisions). Carbide has never had any preferred stock and Dow recently retired a comparatively small preferred stock issue. The one point in common with these three companies has been their strong growth rate.

For several years Du Pont has been building up its cash position. Capital expenditures since 1950 have averaged \$127.5 million a year, but cash available for expansion (the sum of depreciation and net earnings after taxes and preferred and common dividends) has averaged \$172.3 million. In addition, Du Pont invested \$75 million in 1,000,000 shares of General Motors stock (subsequently split 3 for 1 in 1955). Obviously when a company does not even spend all the internally generated cash available, there is no need to go to the outside for capital. This suggests that lack of capital is not the limiting factor but that Du Pont is finding it increasingly more difficult to develop projects which meet management's high return-on-investment objectives. The decision to invest \$75 million in General Motors stock rather than in several chemical projects further strengthens this observation.

On the other hand, Union Carbide and Dow, as well as many other chemical companies, found it impossible to finance the many plants required under the Korean "guns and butter" program entirely through internally generated funds. After paying its common stock dividends, Carbide's cash available for expansion averaged \$63.4 million over the five-year period 1946 through 1950. If capital expenditures had been limited to this amount, Carbide would certainly not be a billion dollar company today, but by borrowing \$300 million from several insurance companies Carbide was able to support a capital expenditure program averaging \$127 million in the five-year period 1951 through 1955. Since much of this expansion was covered by Certificates of Necessity permitting amortization of a substantial portion of the plant over a five-year period (instead of the more normal 10 to 15 years), Carbide's total depreciation charges have been increasing quite rapidly. Total depreciation plus net earnings after taxes in 1955 approximated \$247 million. After deduction

of the \$87.2 million common stock dividends, Carbide has \$160 million available for capital expansion in 1956. It is apparent that insufficient capital was available to Carbide if it wanted to share in the tremendous expansion which has taken place since 1950. When management was faced with the necessity of rejecting sound and profitable projects because of the lack of sufficient internally generated funds, it turned to outside capital. Again it has been demonstrated that capital is not the limiting factor.

Dow is perhaps the outstanding example among the larger chemical companies of a management which will find the capital necessary to expand rapidly. In relation to its size, Dow has spent substantially more money than any of the other large chemical companies, much of it obtained through debt financing. Many institutional investors, accustomed to 30-35 per cent debt ratios in industrial companies, became alarmed when Dow's debt rose over 40 per cent and remained there for several years. Yet the risk was not as great as it seemed when studied in context with world-wide conditions and the circumstances under which the expansion was conducted.

Table 3 compares the Dow results in its fiscal year ending May 31, 1950, just before the Korean War, with the year ending May 31, 1955.

In these five years Dow's capital expenditures totaled approximately \$438 million. Projects covered by Certificates of Necessity totaled approximately \$308 million of which 52 per cent or \$160,000,000 could be written off in five years. To finance this expansion program, Dow used a considerable amount of outside financing:

- (1) \$90,000,000 was borrowed from two insurance companies at 3.25 per cent in 1951.
- (2) \$50,000,000 revolving credit was set up with a number of banks in 1951.
- (3) In July, 1952, Dow sold \$100,000,000 of 3 per cent subordinated convertible debentures to the public. At the time of the sale the common stock was selling at around 39 and the debentures were convertible at 50.
- (4) Common stock was sold each year to employees at prices under the market; this raised approximately \$11.2 million.
- (5) Common stock was sold to stockholders; this raised roughly \$23.8 million.

In the last two years, capital expenditures have been at a lower level than in the three years immediately after Korea. At the same time, cash has been building up due to increased depreciation and amortization charges. As a result Dow has been able to retire some of its senior securities:

- (1) The preferred stock was called at a cost of \$32,500,000 in October, 1954.
- (2) In June, 1955, Dow retired \$62.5 million of its long-term debt.

- (3) \$100 million of bank loans have been retired.

Over the next few years Dow is expected to generate around \$100 million a year which will be available for expansion or repayment of debt. Five years ago this same figure was only slightly over \$40 million. In this 5-year period Dow has built nearly \$440 million of new plants and, because they were covered by Certificates of Necessity, nearly 40 per cent of these new plants will soon be completely written off. Included is extensive expansion in chlorine and caustic soda, ethylene, power plants, water treatment units, and other basic facilities which are generally low-return-on-investment items.

An interesting example of a change in management philosophy is Allied Chemical. Prior to World War II Allied had a greater sales volume than did Union Carbide. However, Allied did not expand as rapidly as others in the industry and consequently fell behind in its relative position in the industry. Capital expenditures were limited to internally generated funds and these were very small in relation to the size of the company. However, with a change in management there was a change in financial policy. In 1952 Allied borrowed \$50 million from the banks and in 1953 sold \$200 million of long-term debt to the public. As was the case with Union Carbide and Dow, many of the Allied projects were covered by Certificates of Necessity. Consequently depreciation and amortization charges, which were only \$14.3 million in 1950, were \$46.0 million in 1955. Retained earnings after payment of common stock dividends amounted to \$24.8 million in 1955. Allied can now finance a capital expenditure program amounting to \$70 million a year without requiring additional outside capital, whereas in 1950 the cash available for expansion amounted to only \$32.8 million.

The Smaller Company

It is apparent that the larger chemical companies have the ability to raise substantial amounts of outside capital whenever internally generated funds are insufficient for the projects on hand. Smaller chemical companies are also able to raise relatively large amounts of capital but they do not have the same amount of choice as to type of security sold as do the larger companies. Financial problems are particularly acute for a very small company which wants to undertake a sizable project.

Raising capital for small chemical companies usually presents some interesting challenges which can probably be best illustrated by a case history.

Northern Chemical Industries was founded in 1943 by Summers Fertilizer to make sulfuric acid and superphosphate at Searsport, Maine. In 1950 an ammonium sulfate plant was added and in 1953 the company built an alum plant to supply pulp and paper companies in Maine and the Maritime Provinces. In its fiscal year ending July 31, 1954, sales amounted to \$1,373,000 and net earnings were \$95,000. Depreciation and retained earnings after payment of dividends amounted to \$95,000. The balance sheet showed net worth to be \$926,000 and there was no long term debt outstanding.

Searsport is roughly 625 miles from Hopewell, Virginia, the nearest source of anhydrous ammonia and nitrogen solutions and the freight rate was \$26.30 a ton which made the delivered price \$114.30 a ton. In addition to the relatively high delivered price, adequate quantities of ammonia could not always be obtained, particularly at the height of the fertilizer season.

In view of this, it is not surprising that the Northern Chemical Industries management considered building an ammonia plant. Most of its sales went to fertilizer companies which would welcome a closer source of ammonia. The paper companies which were now buying NCI alum would also be interested in a closer source of ammonia to avoid the substantial freight charges. Natural gas is not available in Searsport and would be too expensive anyway. No by-product source of hydrogen was available. It was not until development of the Texaco oxidation process which could use oil as a raw material that it became economically feasible to make ammonia at Searsport.

Ammonia is a typical heavy chemical in that return on investment is relatively low. Profit on sales is high, averaging around 35 per cent before taxes, but sales per dollar of investment is low—roughly 45 cents. Capital costs are high as it is impossible to build a small ammonia plant. After a long period of investigation it was decided to build a 125 ton/day ammonia plant, a 60 ton/day nitric acid plant, and a nitrogen solutions plant. Because suitable arrangements could not be made with the local public utility, NCI also had to build its own power plant. The total cost of these facilities including working capital and start-up expenses was estimated at \$8,565,000. Internally generated funds available for expansion was only approximately \$100,000 a year and the cash position was sufficient only for its existing business. As a result all of the \$8,600,000 would have to be raised by outside financing.

Table 3.—Dow Chemical Co.—Comparison of Two Fiscal Years

| | May 31, 1950 | May 31, 1955 | % Increase |
|-------------------------------------|---------------|--------------------------|------------|
| Sales | \$220,830,000 | \$470,742,000 | 113 |
| Depreciation and amortization | 20,300,000 | 73,462,000 | 261 |
| Net earnings after taxes | 33,813,000 | 37,414,000 | 10 |
| Tax rate | 36.6% | 49.0% | |
| Cash available for expansion | 41,934,000 | 87,915,000 | 109 |
| Gross plant | 289,504,000 | 686,912,000 | 138 |
| Invested capital | 271,471,000 | 494,306,000 ¹ | |
| % Debt | 22.2 | 37.9 ¹ | |
| % Preferred | 16.3 | — | |
| % Common and Surplus | 61.3 | 62.1 ¹ | |

¹ As of September 15, 1955 to reflect repayment of debt.

It would have been quite simple for NCI management to reject the project on the grounds that capital was "tight." Yet this was a sound project and integrated extremely well into the NCI operations. Hence the decision was made to seek outside capital even though it meant a certain amount of dilution to the original stockholders.

Raising the capital for this project was a bigger hurdle than it would have been for a larger company. The management had been in the business for a number of years and had a good reputation in the industry. Still the project was so large it was almost like starting a new company. Exhaustive engineering and market reports were required not only by the company but by independent experts. Potential investors made a much more thorough investigation than is generally done when a large established company wants to raise some capital.

It was clear that a substantial amount of the required capital would have to be raised through debt or the project would not be attractive to the stockholders. Since a Certificate of Necessity had been obtained, a rather sizable amount of cash could be generated each year which would permit a fairly rapid repayment of the debt. The amount of senior debt which could be placed was restricted, but a package of junior debt and common stock could be sold. In effect this is a mechanism whereby the prospective stockholders assume some of the debt obligations in return for the opportunity of making substantial capital gains.

Senior debt totaling \$3,500,000 was placed privately—\$1,500,000 of 4 per cent first mortgage notes with two banks and \$2,000,000 of 4½ per cent first

mortgage notes with an insurance company. Since the financial strength of NCI was insufficient to guarantee the repayment of debt, the lenders insisted that NCI sign a contract with Summers Fertilizer which would assure sufficient profits to earn the depreciation and thus generate sufficient funds to retire the debt.

An additional \$5,600,000 was raised by selling units, each consisting of \$1,000 5½ per cent subordinated debentures and 20 shares of common stock at a price of \$6.00 a share. The debentures by themselves would attract only a limited amount of investor interest since they represented fixed income securities of a small company undertaking a large project yet to be constructed. It was therefore necessary to include a certain amount of common stock so that in addition to an immediate return on his investment resulting from the relatively high rate of interest on the debenture, the investor could look forward to the possibility of rather attractive capital gains as well as ultimate return of capital through the sinking fund payments.

Numerous other examples could be cited to prove that the apparent lack of capital need not be a restriction for the good project. A project should not be rejected because "capital is tight." At the same time it is understandable that management should reject a project because it does not offer sufficient return to justify the use of capital. Quite logically those companies which do not wish to use outside financing may find that internally generated funds are sufficient to permit the approval of only high-return-on-investment projects.

Presented at A.I.Ch.E. meeting, Los Angeles, California.

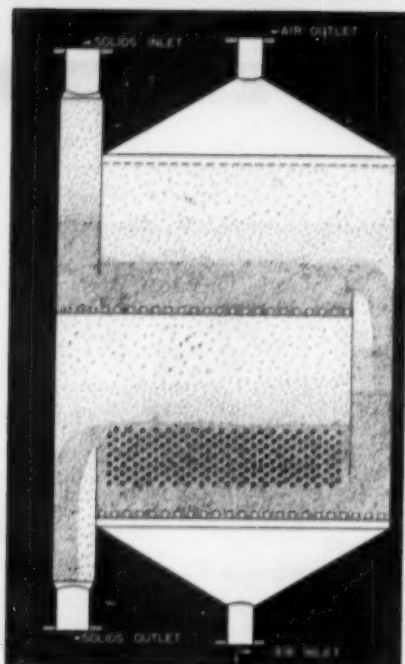


Fig. 2. Rectangular section of bubble-cap tower.

Esso Laboratories have developed a continuous process for adsorptive separation of gases based on the fluidized-solids technique. Finely divided activated charcoal is handled as a fluidized solid in a multistage, bubble-plate adsorption column. The operation is in many respects closely analogous to that of a reboiled oil absorber and has been designated the Fluid Char Adsorption Process (F.C.A.). The pilot plant development of the process and the commercial designs and applications are discussed.

Lewis D. Etherington,* Robert J. Fritz,†
Edward W. Nicholson† and Harold W. Scheeline*

a new fluid-solids development for difficult gas separations: FLUID CHAR ADSORPTION PROCESS

Continuous countercurrent adsorption can be a valuable supplement to conventional separation processes and is particularly applicable to many of the more difficult separations encountered in industry. The general category of adsorption applications includes separation of difficultly condensable gases, recovery and concentration of fluids present in small concentrations, and separation of close boiling materials. Use of solid adsorbents for such separations on a commercial scale has been limited in the past because of the difficulty in obtaining continuous countercurrent contacting of solids and fluid mixtures. The development of the Hypersorption process (1), which utilizes a compact moving bed of adsorbent for continuous countercurrent gas-solids contacting, represented a major advance in the use of solid adsorbents. It was considered that the fluidized-solids technique should likewise be adaptable to adsorptive-gas separations with its simple solids-handling features and its outstanding ability to transfer heat efficiently.

Pilot Plant Studies

Application of the fluidized-solids technique to a continuous gas-adsorption

process represented a considerable departure from normal fluidized-solids operations such as catalytic cracking (2) and fluid hydroforming (3). These two processes were developed around the use of a single, large fluidized bed of catalyst wherein complete solids mixing was desired in order to insure isothermal conditions and the maximum transfer of heat. In the application of the fluidized-solids technique to an adsorption process, it was necessary to obtain stagewise contacting of gas and adsorbent in a plurality of beds arranged as in a conventional bubble-cap tower. This operation would extend further the likening of fluidized solids to true fluids.

In line with these general ideas, the pilot plant work on the Fluid Adsorption process had two principal objectives—namely, (a) development and demonstration of countercurrent staging of gas and solid adsorbent in a type of bubble-cap tower, and (b) the demonstration of satisfactory separation efficiencies within the adsorption tower on typical activated chars and gas feeds. The work on the fluidized-solids problems will be discussed first, and details of the pilot plant and the separation studies will be treated in subsequent sections.

BUBBLE-CAP TOWER FOR FLUIDIZED SOLIDS

The flow of solids in a bubble-cap tower was studied first in a 12-in. diam. glass tower in which the plates, weirs, and downcomers, which were of carbon

steel, could be changed rather simply. The glass tower consisted merely of three plates and the simplest auxiliary equipment for circulating the solids. White cracking catalyst was used at first to aid in the visual observation of the solids flow. The plate spacing was maintained constant in these studies. The tower internals were changed, however, as the studies progressed.

The bubble-cap plates and downcomers in the first tower design were identical with those of a conventional fractionator. Initial runs with this tower resulted in rather low solids throughputs. The stability and smoothness of the plate operation, however, were encouraging. The allowable solids flow rate was gradually increased as various mechanical improvements were made on the tower internals. The volumetric solids rates through the tower that were reached in the final design were, in fact, higher than the corresponding liquid rates normally used in conventional distillation towers. The vapor rates obtainable in the 12-in. tower were in the normal fluidization range, and the entrainment of solids from one tray to the next was not serious even at the higher vapor rates. A sketch of this design is given in Figure 1.

SOLIDS BEHAVIOR IN 12-IN. ADSORPTION TOWER

The tower design which was developed from the glass-column studies was used virtually unchanged in the Fluid Adsorption pilot plant.

The tower was constructed of carbon steel and was operated on a hydrocarbon gas with the use of fluidized char from a petroleum source. Initially,

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manometers were placed on all the adsorber plates to give some idea of stage performance now that no visual means of observation was possible. These manometers were used to measure the solids levels on the plates and the pressure drop across each stage. All the plates behaved in fairly uniform fashion, and soon it was found that one differential pressure recorder across the whole tower gave sufficient indication of the tower performance. Smooth operation was easy to maintain within the tower, and runs of a month's duration were obtained at process conditions.

COMMERCIAL PLATE DESIGN

The 12-in. pilot plant tower did not provide all the design information necessary for a full-scale tower. For example, it was desired to investigate the effect of longer solids flow paths on plate operation, and to explore further the limits of solids and gas rates.

In order to investigate these conditions, a rectangular section of a full-scale plate was constructed. The rectangular section was 10 in. wide and 5 ft. from downcomer to weir. The tower was constructed of Plexiglas, again to permit visual observation, and, where necessary, was reinforced with steel. The tower contained two bubble plates, the lower plate being equipped with 1-in. tubes on representative exchanger spacings as shown in Figure 2.

Commercially attractive solids and gas rates in continuous countercurrent flow were eventually demonstrated in the long, rectangular plate section. One problem that had to be solved was uneven gas distribution over the plate, an effect due to a hydraulic gradient in the fluidized-solids bed. It was found that this difficulty could be overcome by suitable sizing and spacing of the caps.

Some difficulty was encountered in maintaining downcomer seals at low solids rates and high gas velocity. However, the whole plate was active and good stability was indicated over practically the whole range of gas and solids rates studied. This performance indicated a high degree of flexibility for fluidized-solids operations in large diameter bubble towers.

PILOT UNIT FOR PROCESS STUDIES

The basic philosophy used in the design of the Fluid Adsorption pilot plant was to provide a minimum size tower, but one large enough to give separation efficiencies reasonably representative of what could be expected in commercial equipment. In a review of the plate design developed for the glass tower, it was considered desirable not to reduce the adsorber size below 12-in. diam. This tower size dictated a rather large pilot plant from the standpoints of feed-gas and char-circulation rates. The adsorber contained six plates of substan-

tially the same design developed during the glass-tower studies.

The Fluid Adsorption pilot plant was designed to recover C_2 and C_3 hydrocarbons from a refinery residue gas stream. A typical feed composition is shown in Table 1.

A schematic diagram of the pilot unit is given in Figure 3. The feed stream is admitted at about the middle of the six-plate tower, and the circulating char at the top. Heavier components of the feed gas are selectively adsorbed and carried down the tower into a desorber. The char is heated to about 500° F. and contacted with steam to release the adsorbed hydrocarbons. Part of the desorbed hydrocarbons is dried and returned to the bottom or rectification section of the adsorber as "reboil" or reflux vapor to aid in concentrating the heavier hydrocarbons. The remainder of the desorbed hydrocarbons is withdrawn as bottoms product. The lighter components (H_2 , N_2 , CO , and methane) go up the tower and are taken off as the overhead product. (It should be noted that the withdrawal of sidestreams can be readily accomplished in the Fluid Adsorption process.) The char flows from the desorber into a stripper or dehydrator where the steam is stripped from the char by a small recycle portion of the overhead product. The char leaves the stripper and is picked up by a recycle portion of the tower overhead which serves as lift gas. The char is cooled to about 120° F. in a cooler, and is carried to the heads tank at the top of the adsorption tower; thus the cycle of the char flow is completed. The absorber-desorber operation is quite analogous to that of reboiled absorbers and fractionation columns.

A high-temperature reactivator was provided for regenerating deactivated char; a small portion of the circulating char could be withdrawn from the heads tank, passed to the reactivator, cooled and reintroduced into the adsorption system via the lift gas stream. The reactivator has been operated at two temperature levels—namely, 1,000 and 1,400 to 1,500° F. Steam was used as the fluidizing medium. At the higher reactivator temperatures, steam reacts with the deactivants and char.

The pilot plant was operated at pressures up to 80 lb./sq.in. gauge, the maximum pressure at which the refinery residue gas was available. The fluidized-solids technique has been demonstrated commercially at 260 lb./sq.in. gauge in fluid hydroforming (4) so that operation at higher pressures should be easily accomplished in the case of Fluid Adsorption. Temperature averaged about 130° F. at the top of the tower, and increased to roughly 210° F. at the bottom

plate owing to the heat of adsorption. The feed, which could be admitted to any one of the four intermediate trays, usually entered the unit at 70-90° F.

The desorber was heated by means of Dowtherm A vapor condensing inside internal, vertical tubes. The desorber was equipped with two cyclones to remove char fines from the bottoms-product vapor. The bottoms product, containing desorption steam, was passed to a water scrubber to condense the steam and to remove the last traces of solids from the gas stream. The high length to diameter ratio and the heating tubes provided some staging in the desorber.

To provide some countercurrent contacting of the gas and solids, the stripper contained a few internal baffles. Since the volume of stripping gas was rather small, conventional filters were employed to remove solids from the gas. The gas was then passed to a water scrubber and released as a portion of the overhead product.

Table 1.—Typical Adsorber Feed Composition

| composition | mole % |
|-------------|--------|
| H_2 | 12.9 |
| N_2 | 12.8 |
| CO | 1.6 |
| CO_2 | 3.1 |
| H_2S | 0.6 |
| CH_4 | 28.1 |
| C_2H_6 | 7.5 |
| C_3H_8 | 10.3 |
| C_4H_{10} | 17.7 |
| C_5H_{12} | 4.8 |
| C_6H_{14} | 0.1 |
| C_7H_{16} | 0.4 |
| C_{10} | 0.1 |
| | 100.0 |

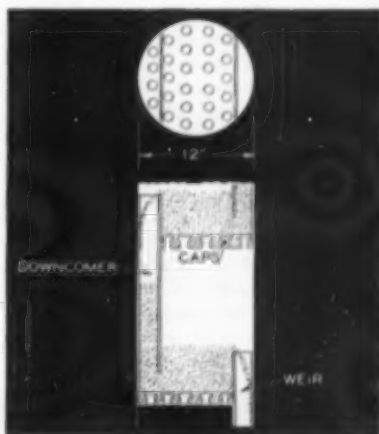


Fig. 1. Sketch of 12-in. diameter glass tower.

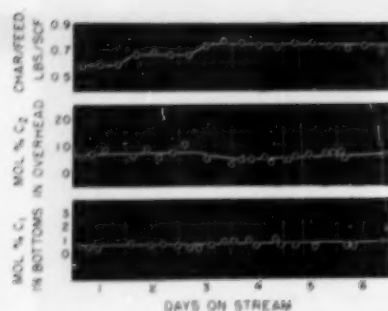


Fig. 4. Adsorption pilot plant—control of product quality.

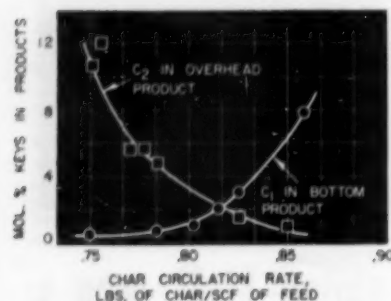


Fig. 5. Effect of char circulation rate on product composition when amount of reboil vapors to tower bottom is held constant.

The remaining pieces of equipment were quite conventional. The adsorber char cooler was cooled with water flowing through internal, vertical tubes. The heads tank was simply a reservoir for the circulating char. It contained also two stages of cyclones to remove entrained solids from the overhead gas. The solids flow was controlled by slide valves. The upper slide valve was operated to maintain a constant differential pressure across the riser, and the lower slide valve (at the bottom of the stripper) was operated on level control in the desorber. Available compressors were used to pressure adsorber reflux and char lift gases; blowers would have been adequate since the pressure differentials were quite low.

In constructing and operating the pilot plant, it was more convenient to have separate vessels in the adsorption system. For commercial designs, however, the heads tanks, adsorber, desorber, and stripper would be combined into a single column with plates for staging in all sections (see Figure 6).

CONTROL AND STABILITY OF ADSORPTION TOWER

The solids flow through the tower was quite smooth. When separating feeds such as represented in Table 1, the composition of the overhead and bottoms product could be readily controlled. For example, a controlled reduction in the char rate reduced the methane concentration in the bottoms from 10 to 1.5% within a period of 20 min. (The

Table 2.—Typical Adsorber Separations

| | | | | | | |
|--|----------|----------|------|------|-------|------|
| Bottoms product | C_{2s} | C_{3s} | | | | |
| Tower pressure, lb./sq.in. gauge | 70 | 80 | | | | |
| Feed rate | Constant | | | | | |
| Char rate (lb. char./std.cu.ft. feed) | 0.66 | 0.41 | | | | |
| Gas analyses, mole % | feed | btms. | OH | feed | btms. | OH |
| Inerts (N_2 , H_2 , CO) | 25.1 | 0.1 | 43.8 | 22.5 | 0.1 | 29.4 |
| C_1 | 27.5 | 1.6 | 46.6 | 30.9 | 1.0 | 40.4 |
| C_2 | 16.7 | 38.1 | 1.1 | 18.6 | 5.9 | 23.7 |
| C_{2s} | 21.3 | 50.4 | 0.1 | 23.2 | 90.6 | 0.6 |
| CO_2 , H_2S | 9.4 | 9.8 | 8.4 | 4.8 | 2.5 | 5.9 |

desorbate reflux rate was held constant during this period so that the bottoms-product rate decreased and the reflux vapor-to-char ratio increased.) Composition of the key components in the overhead and bottoms streams was followed continuously by a monitoring mass spectrometer (5). The spectrometer charts showed that the concentrations of the key components are not subject to short-term fluctuations; this condition indicates again the smooth tower operation which is obtainable. Figure 4 shows that the methane concentration in the bottoms can be easily controlled to less than 1% for a period of days. Changes indicated in the char-to-feed ratio were largely accounted for by changes in operating conditions and changes in feed composition.

ADSORBER SEPARATIONS

The adsorption tower has been operated to recover in the bottoms either C_3 and heavier components or C_2 and heavier. Obviously, if both C_2 and C_3 compounds are to be recovered at a given feed rate, a higher adsorbent rate is required than if only C_3 is to be recovered. This is borne out by the typical separation results given in Table 2 for the six-plate adsorption tower. The char-to-feed ratios noted are not the minimum required for the separations. It should be pointed out also that the small stripper portion of the overhead gas has been included in the overhead product so that the values listed will give an approximate material balance. Some heavier components are desorbed along with water in the hot stripper, which indicates lower adsorber efficiencies than actually realized.

In the C_2 recovery case (C_1 — C_2 separation), the concentration of C_2 's in the overhead was a little more than 1%; the methane content of the bottoms product was 1.6%. Essentially all the CO , N_2 , and H_2 appear in the overhead products inasmuch as these gases are virtually unadsorbed at tower operating conditions. CO_2 and H_2S are adsorbed

to varying degrees and a good percentage of these materials is found in the bottoms products. No effort was made to control the separation on these components. In the C_3 recovery case (C_2 — C_3 separation), about 6 mole % of ethylene and ethane was found in the bottoms product. Fewer C_2 's would have been included with the bottoms if the rate of withdrawal of this product had been lowered (higher reflux) or if the char rate had been reduced while holding the reflux constant. Sharp separations usually were not desired, however, from the standpoint of analytical accuracy and evaluation of adsorber plate efficiency.

An illustration of the effect of changing the char circulation at a given feed rate and at a constant rate of "reboil" vapors to the bottoms of the tower is given in Figure 5. These data were obtained when making a separation between methane and C_2 's during a period of fairly constant feed composition. It can be seen that too low a ratio of char-to-feed results in excessive C_2 's being lost to the overhead product. At the same time, a smaller concentration of methane is found in the bottoms product due to the higher ratio of reflux gas to char. These effects are qualitatively the same as would be encountered in distillation on changing reflux and bottoms withdrawal rates while maintaining constant feed and reboiler vapor rates. The rapid change of key concentrations with adsorbent rate reflects the high char selectivity for C_3 over methane (high relative volatility).

ADSORBER SEPARATION EFFICIENCIES

Estimated separation efficiencies were based on analyses of vapor samples taken from each of the individual plates. The samples, obtained by inserting screen-tipped probes into the tower at a level of about 6 in. above the solids bed, were withdrawn simultaneously from each of the plates, and the amount of vapor withdrawn was negligible relative to that passing up the tower. The over-all

Murphree efficiency for each tray was estimated as follows:

$$E = \frac{Y_n - Y_{n-1}}{Y_n^* - Y_{n-1}}$$

where

Y = mole fraction in a binary fraction of a vapor mixture

Y^* = Y in equilibrium with bulk adsorbate

and

$n, n-1$ = adjacent adsorber stages

Total adsorption and material balances were used for calculating Y_n^* values. The amount of the adsorbed phase was estimated from mixture correlations which are shown in a companion paper (11). The desorber operated quite efficiently, and metered dry-gas desorbate quantities checked total adsorption estimates for the bottom adsorber plate satisfactorily.

In the application of the efficiency equation to the pilot plant results, several assumptions were made. First the complex feed gas as represented in Table I was treated as a six-component system: inerts, CH_4 , CO_2 , C_2H_4 , C_2H_6 , and C_3H_8 . The inerts (H_2 , N_2 , and CO) were assumed to adsorb negligibly at the tower conditions. H_2S , present in rather small quantities, was treated as propane in view of the similarity of

char-adsorption isotherms for these two materials. Propylene was also treated as propane; these hydrocarbons have a relative volatility of 1.0 and almost identical isotherms. Finally, C_4 material was lumped with propane also in view of the relatively small quantities encountered. CO_2 was treated as a separate component. In efficiency calculations, allowance was made for solids-entrained vapor carried downward with the char. The effect of vapor-entrained solids carried up the tower was assumed negligible, based on the glass-tower observations.

Adsorber plate efficiencies estimated for the separations discussed previously are given in Table A.

The precision limits shown represent one standard deviation. In the higher velocity range where the fluidization is generally good, the plate efficiency is essentially 100%. Furthermore, there appears to be no statistically significant difference between the efficiencies reported for the C_1/C_2 separation as compared with the C_2/C_3 separation. In the low gas velocity range, which favors poor fluidization and channeling, the efficiencies on both separations are significantly lower. Under normal operating conditions, plate efficiencies in the order of 100% could be anticipated for the Fluid Adsorption process. It is interesting to note that comparable effi-

| Table A. | | |
|------------------------------------|----------------------------|-------------------------|
| Pilot adsorber gas velocity: | Minimum fluidization range | Commercial design range |
| Plate efficiency (E), % | | |
| C_1/C_2 separation | 69 ± 6 | 96 ± 5 |
| C_2/C_3 separation | 79 ± 1.5 | 100 ± 4 |

ciencies for oil absorbers run as low as 10%.

Simultaneous vapor samples taken at various points from a given adsorber stage indicated no concentration gradients across the plates in the direction of char flow. This was to be expected since the solids path was quite short and, presumably, the plate solids well mixed. Thus, estimated over-all tray efficiencies for the pilot plant adsorber should be representative of local efficiencies. Higher over-all efficiencies might be anticipated for commercial adsorbers due to the longer solids path across the plate and inherent staging on a given tray.

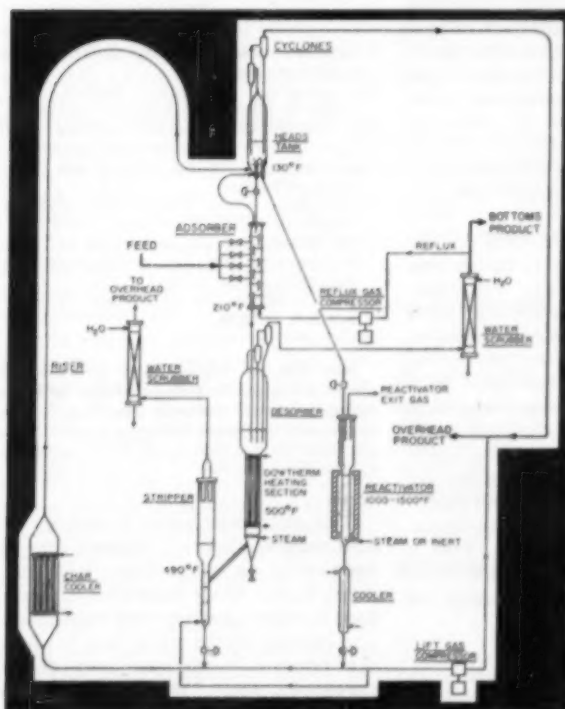


Fig. 3. Fluid adsorption pilot plant.

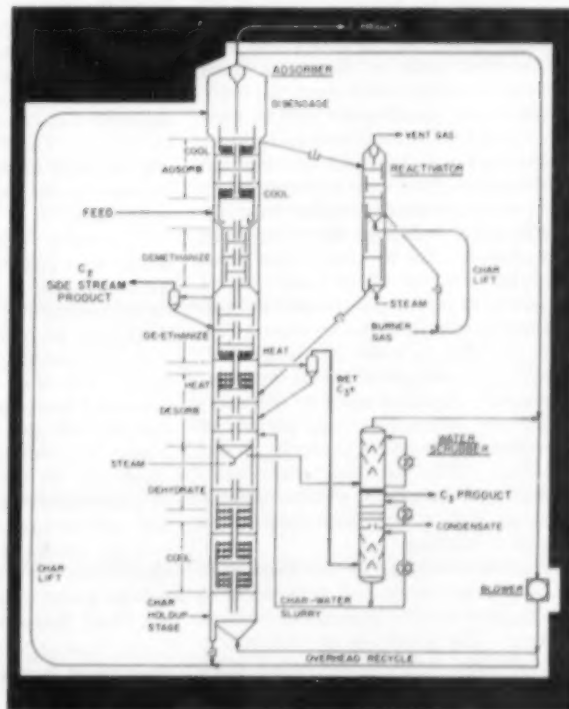


Fig. 6. Commercial fluid adsorption design.

CHAR DEACTIVATION AND REGENERATION

The need for reactivating the char depends largely on the nature of the feed stock. With feeds containing nothing higher in molecular weight than C_3 's, little or no deactivation of the char occurs even after long and continued use. With heavier feeds some deactivation occurs, and the reactivation requirements are best judged after tests on the individual feed. Deactivation can apparently arise from small amounts of heavy ends (C_4 , material) in the feed and from a small amount of polymerization of olefins and diolefins which takes place on the char. Deactivants present in the refinery residue gas feed to the fluid-adsorption pilot plant were comparatively mild; during long runs the char decreased to 75 or 80% of its original adsorption capacity whereupon an equilibrium activity was reached. This activity level was felt to be satisfactory. Higher levels were maintained by high-temperature reactivation with steam. The capacity of the pilot plant char leaving the reactivator is given in an accompanying table along with other characteristics for a period of three months of steady operation. The char activity is shown for periods during which semicontinuous reactivation was employed (see Table B).

The loss in permanent adsorptive capacity during this three-month period of operation was less than 10%, and it is apparent that the char is remarkably stable when the long and varied usage is considered. No trend is evident in the sulfur content of the char, and the slight increase in ash content noted over that of the fresh char is due to a small amount of iron pick-up from the unit.

Laboratory deactivation studies were made on synthetic feeds containing more unsaturated materials, such as butadiene and isoprene, than were encountered in the pilot plant studies. Char deactivation by these feeds was more severe than that observed for the pilot plant char. However, activity of laboratory chars subjected to severe deactivants could be restored to 90% or better by steam treatment at 1,200 to 1,400° F. In general, laboratory reactivation results were encouraging. Repeated adsorber-desorber-reactivator cycles over long periods of operation are required, however, to obtain deactivation-reactivation data representative of cumulative effects. Results obtained with a few laboratory cycles can be misleading.

Considerable progress has been made on a general correlation between char deactivation and the level of contaminant deposits. The prediction of reactivation requirements, however, has been a more difficult problem. For example, at the high temperatures required for regeneration, there may be adverse changes in

the character of deposits such as by polymerization and coking. A better understanding is required of the mechanisms of deactivation and reactivation.

CHAR MAKE-UP REQUIREMENTS

The activated chars used in the Fluid Adsorption pilot plant were in the same general particle size range as that used in fluid catalyst cracking. These small char particles, whether derived from coconut shells or from a petroleum source, are quite resistant to attrition. The pilot plant data indicate that these chars are more resistant to attrition than cracking catalyst, and that less than 0.015% of the char circulated should be lost as a result of attrition and reactivator burning loss. The petroleum-derived char used in the pilot plant could be produced on a small commercial scale at comparatively low cost. Adsorbent make-up costs in terms of this char should not be significant. Make-up in terms of the better commercial chars available, at current small-lot prices, would represent an appreciable operating cost item.

HEAT TRANSFER

The heat transfer surface required to heat and cool the adsorbent represents a principal investment cost in adsorptive processes. One of the outstanding characteristics of any fluidized-solids system is the ease with which heat may be transferred to and from fluid beds. Fortunately, the heat transfer coefficients obtained with activated char are fully as good as those reported for other fluidized-solids systems (6, 7). Data from heat transfer tests on the pilot plant desorber and char cooler are presented in Table C. The fluidization gas velocity was the same for both vessels, and intermediate in the range of gas rates demonstrated.

The water side coefficients in the cooler were calculated from correlations given by McAdams (10). The Dowtherm coefficients in the desorber were calculated from the Kirkbride equation (8) for condensing vapors on vertical tubes. The char side coefficients were calculated in the conventional way from the over-all and the individual coefficients; the estimated char side coefficients for the desorber and cooler are in good agreement. Higher gas velocities and heat transfer rates are visualized for commercial adsorbers. Thus, a design char side coefficient of 100 would appear to be a conservative value for the Fluid Adsorption process.

Commercial Design Studies

The pilot plant system was made up of a rather large number of separate ves-

sels to facilitate process studies. A less complex design was visualized for large-scale separations. One of the alternate commercial F.C.A. designs studied is illustrated in Figure 6, as applied to separation of C_4 , C_3 , and C_2 fractions from light hydrocarbon and inert gas mixtures. Other commercial designs are described in the patent literature (9). The major equipment units are the adsorber, reactivator, solids circulation (gas lift) system, and a water scrubber for simultaneous removal of char fines and desorption steam from gas streams.

The chief functions of the adsorber are the same as described above for the corresponding pilot plant units, except for the additional side stream feature. These include the following:

- 1 Adsorption of heavy key (C_4) and heavier feed components in upper tower section.
- 2 Enrichment of C_3 fraction (demethanizing) in rectification section immediately below feed.
- 3 Withdrawal of C_3 side stream product.
- 4 Enrichment of C_2 fraction (deethanizing) in lower rectification section.
- 5 Withdrawal of wet C_2 product.
- 6 Desorption by heating and steam stripping in next lower tower section.
- 7 Dehydrating hot desorbed char with recycle overhead gas.
- 8 Cooling char in bottom section prior to recirculation.

The char is conveyed to the top gas-solid disengaging section by gas lift, and the net overhead C_4 product is withdrawn from the recycle lift gas line. Other adsorber design features differing from the pilot plant are as follows:

- 1 Internal stage heating and cooling with horizontal coils.
- 2 Cooling in adsorption section, particularly immediately above feed point.
- 3 A necked-down demethanizing section (where low vapor volumes are encountered) to maintain good fluidizing velocities.
- 4 Split-flow plate design to minimize length of solids flow path.
- 5 Secondary heating at bottom of rectification section to avoid excessive desorber vapor volumes.
- 6 Wet reflux vapor to bottom of rectification section.

Note that the internal tower cone prevents contamination of the bottoms product with dehydrator (recycle overhead) gas. The C_4 side stream may be treated further in a small separate adsorber for clean-up of small equilibrium C_4 quantities (9a, 9b).

The char reactivator is staged for maximum efficiency. Preheated char is removed at an intermediate reactivator stage, heated to the maximum temperature by direct contact with combustion gas external to the tower in a lift line, and returned to the reactivator at the withdrawal stage. The combustion gas passes up the tower to preheat down-flowing char and to strip any desorbable

deactivants to minimize cracking. The hotter char from the withdrawal stage is contacted with steam in the two bottom stages for final reactivation by the water-gas reaction. The hot reactivated char is returned to the desorber heating stage.

Residual char fines and steam are removed from the bottoms product and dehydrating gas in two isolated sections of a water scrubber. The C_3 , adsorber product contains a high steam content. This steam is partially condensed in the fines removal section to control the slurry concentration. The remaining portion is condensed in the absence of fines (9c). The net fines recovered are returned to the bottom desorber stage as a concentrated water slurry.

Applications—F.C.A. Process

Adsorbent carbons are most selective for vapors according to boiling point rather than to polarity or degree of unsaturation. For example, activated charcoal is quite selective for ethylene in preference to methane. The char separation factor for the ethylene-ethane binary, however, is not much better than in low-temperature distillation. In order that adsorption be competitive with conventional processes for gas separations, the adsorbent must have relatively high selectivities and adsorption capacities for the key components. This is the case for the separation of methane and ethylene inasmuch as the char adsorption relative volatility for methane-ethylene is as high as 14 at atmospheric conditions (11). As discussed previously, fluid char adsorber plate efficiencies for this binary are in the range of 100%. Thus, sharp separations may be made with few stages.

Berg (1) has pointed out the high retention of light hydrocarbons by activated char relative to absorber oil. For example, char capacity for ethane may be as much as twenty times that of absorber oil (lb./lb. basis) at substantial pressures. This figure is a rough index of required char circulation, relative to that of absorber oil, for light hydrocarbon separations such as $C_1 - C_2$. Higher pressures and expensive low-temperature refrigeration are required to bring oil capacities in line with those of the warmer char, and to make separation by distillation practical. The separation of difficultly condensable gases, therefore, is one of the most promising applications of the F.C.A. process.

Absorber oil capacities for higher boiling materials approach those of activated char even at moderate pressures. Also, the higher boiling mixtures usually are easily separated by distillation. In general, gas adsorption is not competi-

tive with conventional techniques for separating such mixtures. At low partial pressures, however, even high boiling materials are retained by activated char to a degree much higher than by absorber oils. Thus, there are quite a few cases in which gas adsorption may be applied advantageously for recovery and concentration of materials boiling much higher than the lighter hydrocarbons. A familiar, fixed-bed example is recovery of small concentrations of benzene from air or from other relatively inert gases.

Some of the most promising applications of the F.C.A. process, falling in the two major categories just discussed, are listed as follows:

- 1 Separation of C_2 and C_3 fractions from refinery residue (fuel) gas and from natural gas.
- 2 Purification of hydrogen in recycle operations or hydrogen as derived from hydroforming and ethane cracking for ethylene production.
- 3 Concentration of acetylene produced by partial combustion or severe cracking of light hydrocarbons.
- 4 Recovery of solvent vapors and other valuable materials present in small concentrations in air and in other inert gases.
- 5 Gas drying.
- 6 Recovery of light ends from hydrocarbon synthesis reactions.

F.C.A. Process—Special Features

Advantages of the fluidized-solids technique as applied to catalytic-cracking and other oil-refining processes are well recognized. The outstanding features of the F.C.A. process attributed to fluidized-solids handling, as indicated by the pilot plant data discussed previously, are summarized as follows:

- 1 A small adsorbent inventory.
- 2 High heat transfer coefficients for solids heating and cooling.
- 3 High allowable vapor and solids velocities, which minimize tower volumes.

- 4 Adaptability to stagewise cooling in the adsorption section and heating in the lower rectification section (minimum required char circulation rates, exchanger surface and utilities).
- 5 Direct char heating with combustion gas in reactivation operations, which minimizes high-temperature equipment problems.
- 6 Simple and effective means for solid flow control.
- 7 Continuous operation which does not require multiple equipment units.

These special features go a long way towards eliminating the limitations of gas adsorption inherent in the older fixed-bed technique.

F.C.A.—Development Status

The essential features of the adsorptive separation system have been demonstrated quite satisfactorily on a pilot plant scale. These include solids flow and general process control, multistage gas solids contacting, adsorption-desorption efficiencies, heat transfer rates, char attrition losses, and vessel erosion. The large cross-flow plate study results should be fairly representative of commercial adsorbers as large as 10-ft. diam., with split-flow plates.

The major F.C.A. feature requiring further development is adsorbent reactivation. This applies particularly to separations on feeds containing severe deactivants. Examples of such feeds are those containing higher acetylenes, diolefins, excessive C_6 , olefins, and appreciable quantities of C_8 , heavy ends. Commercial reactivator designs of the type just described require demonstration of reactivation efficiency and char regeneration losses for the more severely deactivating feeds mentioned. Also,

Table B.

| Days of operation on char | 0 | 45 | 60 | 73 | 87 |
|---|-------|-----|-------|------|-----|
| C_2 adsorptive capacity, % of initial | 100 | 97 | 93 | 93 | 92 |
| Surface area, sq.m./g. | 1,020 | 985 | 1,000 | 987 | ... |
| Sulfur, wt. % | 2.2 | 1.6 | 2.0 | 1.6 | 2.4 |
| Ash, wt. % | 0.7 | 1.1 | 1.1 | 0.90 | 1.0 |

Table C.

| | Desorber | Char cooler |
|--|----------|-------------|
| Over-all coefficient, B.t.u./hr./sq.ft./° F. | 68-75 | 80-90 |
| Calc. water side coefficient | ... | 315-320 |
| Calc. Dowtherm coefficient | 185-210 | ... |
| Calc. char side coefficient | 95-115 | 100-125 |

further study is indicated on other F.C.A. features in order to arrive at the most efficient and economical process. Examples are alternate exchanger-plate designs and dust-removal methods.

It is felt that the present F.C.A. development is adequate for commercial separation of feeds containing only mild deactivants. Based on present experience, no char reactivation should be required for gas adsorber feeds characterized as follows:

- 1 No unsaturates other than ethylene, propylene, and acetylene.
- 2 No materials higher boiling than C_5^* .

The concentration of hydroformer hydrogen represents an immediate application of Fluid Adsorption.

* Higher boiling nonpolymerizing materials (benzene, toluene, and hexane, for example) could be tolerated without regeneration. However, such materials boiling appreciably higher than the key feed component might increase desorption requirements or lower the equilibrium adsorbent activity excessively.

Cost studies have been made on the F.C.A. process for several refinery applications. These included separation of light hydrocarbon fractions, such as methane and C_2 's from fuel gas, and purification of hydroformer hydrogen (hydrogen-methane separations). However, since F.C.A. costs vary with such factors as adsorption pressure and concentration of key components in the feed and especially with the amount and nature of char deactivants which may be present, a detailed engineering and cost study would be necessary to evaluate the process for any specific industrial application.

Acknowledgments

The authors wish to express their appreciation to the Esso Research and Engineering Company for permission to publish this paper, and to the individuals who contributed to the various phases of the over-all study.

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Literature Cited

1. Berg, Clyde, *Trans. Am. Inst. Chem. Engrs.*, **42**, 665 (1946).
2. Murphree, E. V., et al., *J. Inst. Pet.*, **33**, 286; 608 (1947).
3. Shephardson, R. M., et al., *Proc. Am. Pet. Inst.*, **32M(III)**, 224 (1952).
4. Seebold, J. E., et al., *ibid.*, 232 (1952).
5. Lanneau, K. P., *Ind. Eng. Chem.*, **45**, 2381 (1953).
6. Baerg, A., et al., *Can. J. Res. Sect. F.*, **28**, 287 (1950).
7. Rex, W. A., M.S. Thesis, Newark College of Engineering, Newark, New Jersey (1952).
8. Kirkbride, C. G., *Trans. Am. Inst. Chem. Engrs.*, **30**, 170 (1933).
9. U. S. Patent 2,614,657; 2,633,207; 2,666,550; (9a) 2,523,149; (9b) 2,495,842; (9c) 2,681,125.
10. McAdams, W. H., "Heat Transmission," 2 edition, McGraw-Hill Book Company, New York, (1942).
11. Etherington, L. D., et al., *A.I.Ch.E. Journal*, **2**, 65 (1956).

What's in

Symposium Series Volume 50

(Series 15—"Mineral Engineering Techniques")

Chemical Engineering Progress Symposium Series No. 13 concludes with this issue. No. 16, Mass Transfer—Transport Properties, was abstracted in 1955.

Details of Industrial Flotation

G. Gutzait

It is theoretically possible to apply flotation procedures to the separation of a multitude of substances. Aside from the field of mineral beneficiation, where flotation methods originated and are being expanded to new uses and constantly increasing tonnages, a number of proposals have been made—and often successfully applied—involving flotation as a unit operation in chemical processing. Whether or not flotation can be used to achieve a given separation is mostly a matter of economics. A short review cannot possibly discuss the abundant patent literature. A choice has to be made on the basis of practicability, originality of conception, and potential value. A few typical examples are therefore given.

Applications of the Wet Cyclone in Florida Phosphate Operations

H. W. Adam and P. E. McGarry

The wet cyclone is a device for classifying or dewatering liquid pulps. Cyclones are not new, but the application of wet cyclones to ore-dressing problems is relatively recent. Testing of wet cyclones in the phosphate operations is generally a matter of determining the best operating conditions and economics for any specific sizing or dewatering job and comparing the results with other devices such as hydroseparators and screw classifiers. In the test program carried out at the International Minerals and Chemical Noralyn flotation plant, wet cyclones were used where the principal object was (1) desliming, (2) sizing or classifying, (3) dewatering or thickening, or (4) breaking down of tenacious flotation-froth products or agglomerates. One other application of the wet cyclone

is in heavy-media separations, especially in coal and iron-ore beneficiation.

Heavy-Media Separation as Related to the Chemical Industries

R. W. Hurlund

The process of heavy-media separation has been so successfully adapted to the treatment of a wide variety of minerals that chances seem good for successful application to processing within the chemical industries. The application of heavy-media processing requires plant facilities that generally include (1) a feed-preparation section for crushing, sizing, and washing of feed, (2) a heavy-media section proper, and (3) a section for disposing of heavy-media products. The article tells the story of an interesting coal-washing problem solved with heavy-media separation and gives an account of iron beneficiation by heavy-media separation in Austria.

The highlights of a development program which led to an installation of a commercial benzene hexachloride reactor in early 1949 and an improved version in 1951 are reported. Produced primarily by the photochemical addition reaction of benzene and chlorine, the gamma isomer of BHC aroused considerable interest about ten years ago when its practical insecticidal value became known, specifically in the application to control the cotton boll weevil. At that time not much had been reported on the application of photochemical energy to promote this reaction for the commercial production of BHC. Today the BHC reactor is regarded as an efficient apparatus for gamma BHC production, especially when the over-all plant investments are considered. It is the authors' hope that the development program presented here will benefit future workers and will encourage the publication of their work in the general field of photochemical reactor designs.

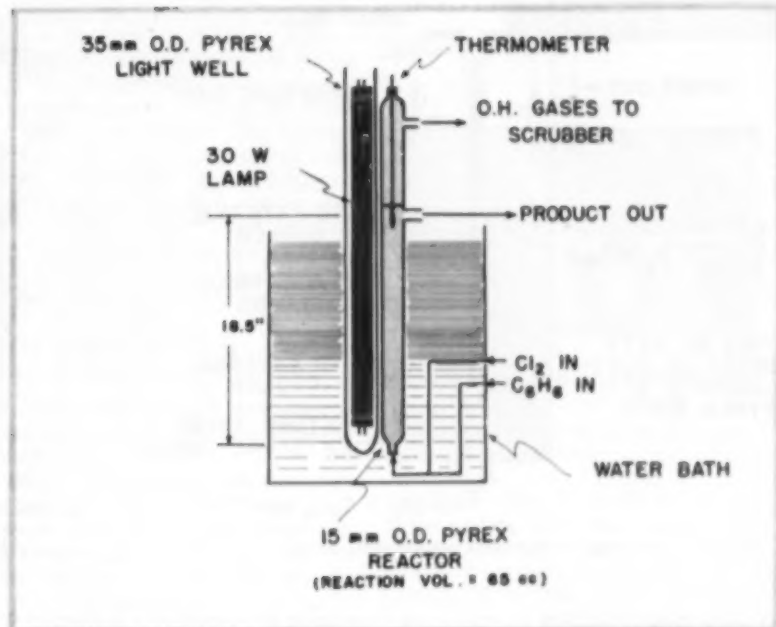


Fig. 1. Exploratory BHC reactor—flooded continuous.

DEVELOPMENT OF A TWO-STAGE BHC PHOTOCHEMICAL REACTOR

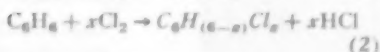
L. J. Governale and J. T. Clarke

Ethyl Corporation, Baton Rouge, Louisiana

This discussion will cover (1) the exploratory testing phase lasting a period of two months, (2) the pilot scale testing requiring a second two-month period, (3) the semicommercial operation, and (4) the highlights of a fundamental test program which led to the final development of a two-stage BHC reactor.

Prior Knowledge

It was known prior to starting the exploratory work that two general species of reactions, shown below, are possible between benzene and chlorine in a BHC reactor:



The first of these reactions, which produces benzene hexachloride, is normally catalyzed by light and is a complete addition reaction. However, it was known that as many as five stereoisomers of BHC are formed by this reaction

and that the gamma isomer, which is the only isomer having any insecticidal value and is the isomer for which BHC is valued, is present usually in poor yields of 10%-13%. There were no explanations or theories advanced at this time on the reason for obtaining these low yields. Apparently there had not been sufficient incentive up to this time to improve the yield of the gamma isomer in this reaction.

The second reaction covers the undesired chlorobenzene substitution reactions which produce a mole of hydrogen chloride for every chlorine atom substituted on the benzene ring. This reaction is normally carried out in the dark in the presence of a Friedel Craft catalyst such as ferric chloride or aluminum chloride.

Both chlorine and benzene hexachloride are soluble to an appreciable degree in benzene, and it was possible to consider a reactor design based on a homogeneous liquid-phase system. Also known was the fact that the BHC reaction is a chain reaction initiated by

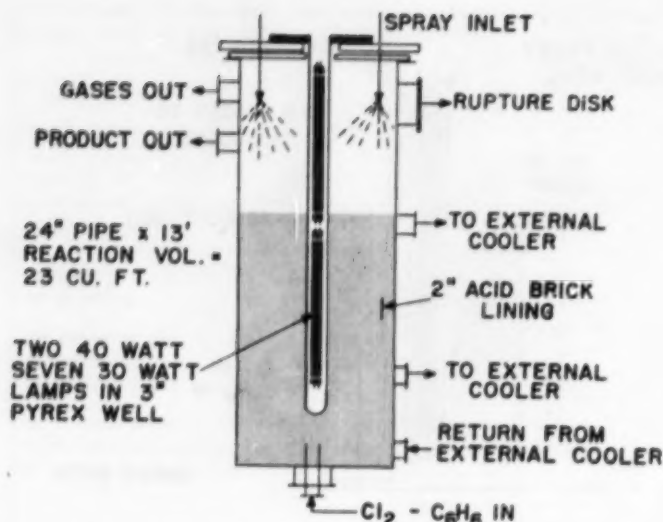


Fig. 2. Pilot plant pot type BHC reactor.

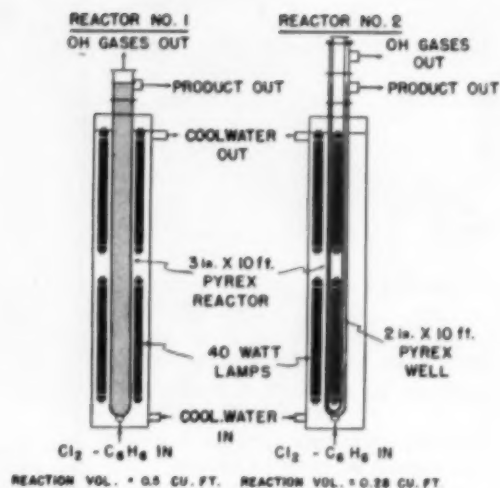


Fig. 3. Pilot plant tube type BHC reactors.

chlorine atoms which are formed by the photo-dissociation of chlorine (Cl_2) by light of a wavelength less than 4800 \AA (12).

Previous experience also disclosed that certain inhibitors, such as oxygenated compounds, could be present in chlorine. Methods were available for

removing these inhibitors in chlorine by passing the gas through an activated alumina bed.

Exploratory Testing Phase

First efforts toward developing a BHC reactor were directed to obtain answers to such questions as: (1) what

percentage of substitution products will result? (2) what are approximate chlorine conversion rates in a well-lighted reactor? and (3) what operability problems may be encountered in a plant reactor? Several simple laboratory reactors were tested. Typical of these reactors is the one shown in Figure 1.

Other reactors similar to this one were set up to test the effect on light transmission of replacing the Pyrex reactor with a quartz reactor and removing the light well. Larger reactor volumes, charging benzene batchwise while feeding chlorine continuously, and feeding benzene in as a spray phase while feeding chlorine in at the bottom, were also tested.

Typical data obtained from this exploratory work are given in Table 1. These data are significant only within the comparisons which are made. The reactors were generally run in the temperature range of 30 to 60°C . Light wattage used was a 30-w. fluorescent lamp in all cases. The ranges on chlorine reaction rates represent total chlorine converted to both substitution and BHC products and the chlorine converted to BHC alone. Use of pure benzene in the second test in Reactor No. 1 gave a reduction in the substitution reaction. This was studied more fully in other tests.

For the flooded reactors there appears to be some correlation between initial chlorine feed concentration and over-all conversion rate, as might be expected. The concentration shown for Reactor No. 3 is based on total chlorine fed divided by the amount of benzene charged. In this test a 13-min. induction period was noted. The chlorine going to substitution reactions was not measured during the induction period, which ex-

Table 1.—Typical Data for Exploratory Test in BHC Laboratory Reactors

| Reactor | Volume cc. | Benzene source | Feed wt. % chlorine | Chlorine converted lb./cu.ft./hr. | |
|----------------------|---------------|-------------------|-----------------------------|---|--------|
| | | | | total | to BHC |
| 1 (Flooded cont.) | 65 | ind. benzol | 20 | 118 | 83 |
| 1 (Flooded cont.) | 65 | pure benzene | 10 | 55 | 47 |
| 2 (Flooded cont.) | 215 | ind. benzol | 4 | 18 | 4 |
| 3 (Flooded batch) | 850 | " | 35 | 16 | 15 |
| 4 (Flooded batch) | 17,500 | " | Cooling capacity inadequate | | |
| 5 (Spray phase) | 1,500 | " | 13 | 4 | 0.6 |

Table 2.—Typical Data for Pilot Scale BHC Reactors

| Reactor | Volume cu.ft. | Feed wt. % chlorine | Chlorine converted lb./cu.ft./hr. |
|---|------------------|---------------------------|---|
| pot (batch) | 31 | 10 | 1-2 |
| pot (spray) | 31 | 15 | 1-1.5 |
| tube (lights external) | 0.5 | 15-20 | 36 |
| tube (lights external and internal) | 0.28 | 15 | 58 |

plains the small difference between the total chlorine substituted and chlorine converted to BHC while using industrial benzol. This induction period encountered in batch reaction was studied more fully in other tests. Poor conversion rates were obtained with the spray phase reactor with the use of benzene feed as source of spray.

Conclusions drawn from these exploratory tests on laboratory reactors were:

1. With proper light distribution, commercial chlorination rates could be realized in practical size plant equipment.
2. Substitution reactions were not a function of normal reactor design but rather of benzene purity.
3. Induction period encountered in batch reactions is a function of the impurities present in benzene and a function of the initial volume of the benzene batch.
4. Little addition reaction occurs in a blocked-out reactor, that is, without benefit of catalysts.

Pilot Scale Testing

Based on these tests large pilot-scale test reactors were considered for the next test phase. Two general reactor types were considered—namely, a pot type and a tube type. Shown in Figure 2 is the pot type reactor which was tested. This reactor was set up to be operated as a flooded-batch or as a spray-phase reactor. Cooling was effected by pumping a solution through an external drip-cooled Karbate exchanger. Solution was returned to the bottom nozzle while the level in the pot was varied from the top nozzle for flooded operation or to the bottom nozzle for the spray phase.

Two variations of the tube-type reactor (Figure 3) were tested.

Typical data obtained in the testing of these reactors are shown in Table 2. Conversion capacities shown for the pot type were disappointing when compared with the exploratory test results shown on Table 2 for Reactor No. 3 where eight to ten times these rates were obtained. The second of the tube-type reactors gave the highest conversion rate of 58 lb./hr. (cu.ft.) based on available reaction volume, but this advantage over the first tube type is balanced out by the fact that its volume is reduced by the internal light well.

The general conclusions from this pilot scale testing were as follows:

1. Fluorescent lamps of 10 w./ft. were quite practical and economical for large-scale reactor design.
2. The tube reactor appeared to be most readily adapted to commercial exploitation.
3. Reactor cooling should be accomplished as far as possible *in situ* to avoid the problems which had been encountered with maintaining seals on an external cooling system.

Semicommercial Development Phase

For the third or semicommercial phase, which was entered into early in 1949, a trombone-type, drip-cooled tubular reactor, shown in Figure 4, was constructed and operated. (See Figure 4-a for actual photograph.)

Initially this reactor was operated in the open in order to take advantage of sunlight activation during the daytime. Conversion rates were sufficiently high during these times as to exceed cooling capacity. However, this resulted in the discovery that during these times gamma yield was significantly reduced. This is clearly shown in Figure 5 where gamma concentration produced is plotted against

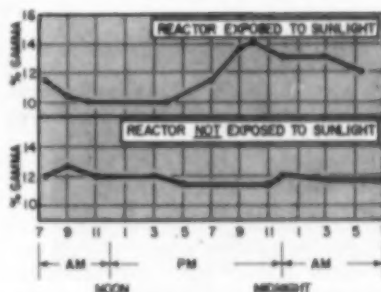


Fig. 5. Gamma variation in semi-commercial plant.

the time of day. With the reactor exposed during the day, gamma percentage, shown in the top graph, dropped to 10% from a usual average of 12 to 14% during the dark periods. With the reactor covered with a tarpaulin on another day, gamma percentages throughout the 24-hr. period, as shown in the bottom graph, were consistent within the analytical accuracy.

It was also learned that an iron oxide film which was deposited on the tubes by the cooling water seriously affected light transmission. An effective remedy for this was developed which consisted of a periodic washdown of the tubes with a 10% hydrochloric acid solution. Conversion capacity of this reactor was ultimately determined to be around 150 lb./hr. or 30 lb./hr. (cu.ft.). This compared favorably with the results obtained with the tube-type reactor shown in Table 2 where a 36 lb./hr. (cu.ft.) rate was obtained. The conclusions

Fig. 4. Semicommercial tubular reactor.

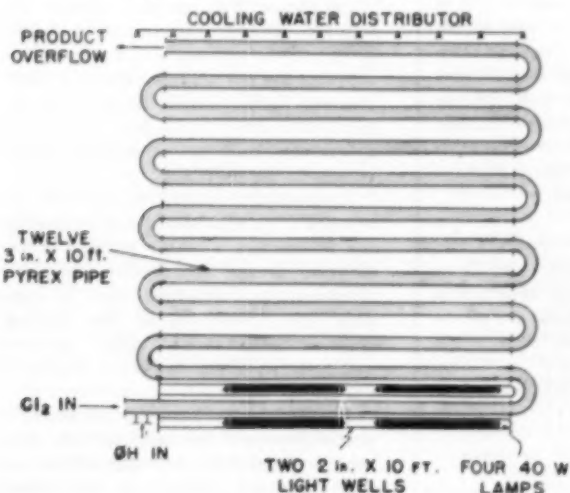
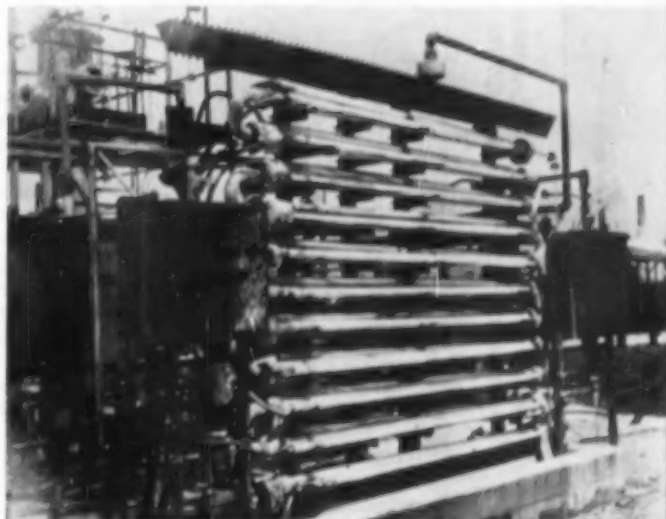


Fig. 4a. Photograph of semicommercial tubular reactor.



from the semicommercial development were:

1. Tube reactor with internal lights would eliminate problem of reduced light transmission owing to fouling of the tube surface.
2. Light intensity appeared to have some effect, direct or indirect, on gamma content in the BHC produced.
3. Conversion rates in a Pyrex trombone-tube reactor can be limited by heat transfer rate through Pyrex.

Two-stage Reactor Development

In considering an expansion of BHC production facilities, a program was undertaken to study more thoroughly the fundamental factors influencing gamma production and over-all reaction rates in a BHC reactor and to obtain data for the design of an efficient gamma reactor. It should be mentioned here

that by this time many developments (3, 4, 5, 8) had shown that gamma content could be improved by catalytic means in dark reactions as well as photochemical reactions.

Details of this fundamental program will be covered in a paper which is planned for publication. The conclusions of this work which are most pertinent here are shown in the accompanying table.

Specific reaction velocity constants k , based on first-order reaction with respect to chlorine concentration and calculated as a differential change in chlorine concentration / (minute) (chlorine concentration) were determined in batch reactions and in a one-stage, pot-type continuous reactor. Average values of k around 1.50 min.^{-1} for chlorine concentrations above 1% were obtained while concentrations from 1 to 0.1%

gave an average value around 1.0 min.^{-1} . These results were obtained with a 30-w. G.E. "blue" fluorescent lamp irradiating through a 2-in. Pyrex well to a 2-in. thick annular reactor volume. This lamp referred to previously was found to give the highest reaction velocity constants. Other tests conducted on light absorption showed that essentially all the light from G.E. "blue" lamp is absorbed within 1 in. of the reactor volume from the light surface.

It can be concluded therefore that reaction is initiated primarily at the light surface and that agitation is a prime factor in transferring chlorine from zones of no light absorption to zones of high photochemical activity, particularly where distance away from the light exceeds 1 in. This effect of light intensity on reaction rate is shown on Figure 6 where k is shown to vary approximately linearly with light intensity.

Two basic problems were confronted in the design of an efficient gamma BHC reactor. The first and more important of these problems involved designing for the lowest practical operating temperature in order that gamma formation would be optimum. The second problem involved designing for maximum chlorine conversion so that cleanup of the reaction product would be minimized.

For a liquid phase benzene-BHC-chlorine system, temperatures in the neighborhood of 32°F. would probably be the lowest practical minimum operating temperature. According to studies at Ethyl this would produce 18-19% gamma BHC. In order to minimize the over-all investment required for recovery and recycle of benzene, it was necessary to design a reaction system having a maximum of 15% BHC in solution which would limit minimum reaction temperature to between 70 and 80°F. , the crystal point of the solution.

The patent literature (2, 1, 7, 9) has since shown that solvent systems are possible whereby temperatures below 32°F. can be realized with a proportionate increase in gamma concentration. However, unfortunately, there is insufficient information in the patent literature to evaluate fully the commercial possibilities of these systems.

A two-stage reactor was finally developed (10) with the first stage operating to convert a major portion of the chlorine under controlled temperature conditions and a second stage to complete the conversion of the residual chlorine from the first stage. A schematic sketch of the two-stage reactor is shown on Figure 7.

For temperature-control purposes, it probably would be best for the first stage to employ a continuous stirred pot with external cooling to supplement jacket cooling on the pot. However, in

RESULTS OF FUNDAMENTAL STUDIES

| | RATE OF PHOTOCHEMICAL ADDITION OF CHLORINE | PER CENT GAMMA BHC |
|------------------------|---|---|
| TEMPERATURE | At moderate light intensities (2,000 ft.-c) the rate of reaction does not vary appreciably with temperature; for low light intensities (500 ft.-c at 30°C. or 200 ft.-c at 60°C.) the rate appears to increase with temperature. | The per cent gamma formed depends primarily on the temperature at which the reaction is carried out. It decreases approximately in a linear manner from 16% at 15°C. to 12-13% at 60°C. This effect has been noted by others in the patent literature (3) although the linear relationship established was for other systems involving solvents. |
| CHLORINE CONCENTRATION | The rate of reaction appears to be first order with respect to chlorine, although the first-order constant seems to increase slightly with increasing initial chlorine concentration. | Although there may be some indication that chlorine concentration had some effect on gamma formation, the effect was relatively minor within the ranges of 1.5 to 7.0 mole % Cl. In view of this and the fact that high concentrations promote high reaction rates and consequently high temperatures, it was considered desirable to operate with a low concentration gradient to avoid localized high reaction rates. |
| WAVELENGTH | Tests with various fluorescent and filtered incandescent light sources showed that only light having a wavelength less than 5000 \AA made any appreciable contribution to the BHC reaction. G. E. "blue" fluorescent lights having a maximum intensity at $4,400 \text{ \AA}$ gave a reaction velocity constant twice that of "white" fluorescent lights. | Varying wavelength between $3600\text{-}500 \text{ \AA}$ did not affect gamma formation. One cannot explain the difference between these results and those reported in German patent literature (11) which indicate otherwise. |

view of the difficulty of insuring the proper distribution of photochemical light in order to get maximum efficiency of the reaction volume in a pot-type reactor, as demonstrated in the tests, the design which was developed involved a tube- or pipe-type reactor with internal light in which the ratio of average light intensity/2 in. thick segment of reactor volume was constant and geometrically similar to the test equipment. In order to achieve temperature control within the first stage or, in effect, to control the maximum reaction rate at any point such that the reaction heat evolved is equal to or less than the heat removal capacity, a recycle from the outlet of the first stage to the inlet was considered. This recycle would accomplish several objectives:

- 1 Reduce the initial chlorine concentration within the reactor, thereby providing control of the maximum reaction rate.
- 2 Create a turbulence within the reactor such that localized reactions and consequently localized high temperatures, especially near the light surface, would be kept to an insignificant level.
- 3 Increase heat transfer rates by the increased liquid velocities.

For the second stage or cleanup section of the reactor, no recycle was employed in order to take full advantage of initial chlorine concentration. The conversion split between the two stages was designed, however, such that the reaction rate which would be realized in the cleanup section would not exceed heat removal capacity at the desired reaction temperature.

A comparison of the effects obtained in a typical two-stage reactor is represented on Figure 8. Two curves are shown based on an initial feed of 15 wt. % Cl. Curve A is for a two-stage reactor employing a 10:1 recycle in the first stage which would result in an initial chlorine concentration of 2.75 wt. % with the inlet to the second stage set at 1.5 wt. %. The outlet from the second stage is set at 0.05 wt. %. The theoretical split on volumes here is 66% to convert 90% of the chlorine and 34% for the cleanup section. Curve B is for a reactor with no recycle where the initial chlorine concentration within the reactor is the feed concentration of 15 wt. %. The theoretical volume required here is only 57% of that required for the two-stage. However, as mentioned previously, agitation should be beneficial in a reactor where light paths exceed 1 in. and, therefore, the actual reactor volume for no recycle would very likely be higher than this percentage.

The commercial reactor (6) developed from these results, which is shown schematically on Figure 9, consisted of thirteen reactor tubes in the recycle section and 5 tubes in the cleanup section. Each reactor tube consisted of a concentric arrangement of a 2-in. Pyrex tube in

which were inserted two 40-w. fluorescent lamps, a 4-in. Karbate tube enclosing the reactor section, and an 8-in. steel pipe enclosing the cooling section. Chilled water at 60° F., circulated in the annular section enclosed by the steel pipe, removed the heat of reaction which was estimated and checked calorimetrically to be around 190,000 B.t.u./lb.mole BHC. A reaction velocity constant of 1.5 min⁻¹ was used throughout although a lower constant should probably apply for the cleanup section. This reactor had a chlorine conversion capacity of around 600 lb./hr. and produced 14 to 15% gamma BHC operating at temperatures in the range 90 to 110° F. Actual design feed concentration was around 11 wt. % Cl in order to keep the resulting BHC level below 15 wt. % of the reactor.

Acknowledgments

The authors wish to acknowledge the work of the many people at the Ethyl Corporation who were involved in this development program and who made this paper possible. Particular mention should be made of J. H. Dunn and S. N. Hall. The authors also wish to acknowledge the valuable assistance given by M. F. Gautreaux and J. T. Balhoff in their critical review of this paper. Acknowledgment is also made of the kind assistance of Rose E. Pilcher, R. M. Boudreaux and H. Doherty in the preparation of the slides.

Literature Cited

1. U.S. 2,513,092, June 27, 1950, Gonze, Max, assignor to Solvay & Cie.
2. British 678,577, January 19, 1951. Inventors: Oswald A. M. G. Roels and George McConnell, assignor to Imperial Chemical Industries.
3. U.S. 2,555,809, June 5, 1951, Kolka, A. J., and Harold Orloff, assignors to Ethyl Corporation.
4. U.S. 2,558,363, June 26, 1951, Kolka, A. J., and Harold Orloff, assignors to Ethyl Corporation.
5. U.S. 2,559,569, July 3, 1951, Orloff, Harold, assignor to Ethyl Corporation.
6. U.S. 2,662,186, January 23, 1952, Governale, Luke J., Albert B. Horn, Jr., and Harry E. O'Connell, assignors to Ethyl Corporation.
7. U.S. 2,628,260, February 10, 1953, Britton, Edgar C., Francis H. Alquist and Kenneth C. Kauer, assignors to The Dow Chemical Company.
8. U.S. 2,691,031, October 5, 1954, Orloff, Harold, and Kelvin J. Warrel, assignors to Ethyl Corporation.
9. U.S. 2,717,238, September 8, 1955, Neubauer, J. A., Franklin Strain and Frederick E. Kring, assignors to Columbia-Southern Chemical Corporation.
10. U.S. 2,729,603, January 3, 1956, Clarke, John T., and Stephen N. Hall, assignors to Ethyl Corporation.
11. German Published Application, April 3, 1952, Badische Anilin und Soda-Fabrik.
12. Rollefson, G. K., and Melton Burton, "Photochemistry and Mechanism of Chemical Reactions," Prentice-Hall (1939).

Presented at A.I.Ch.E. meeting, New Orleans, Louisiana.

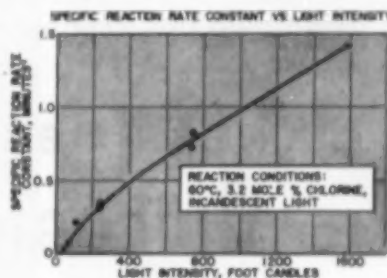


Fig. 6. Specific reaction rate constant vs. light intensity.

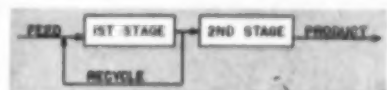


Fig. 7. Two-stage recycle reactor.

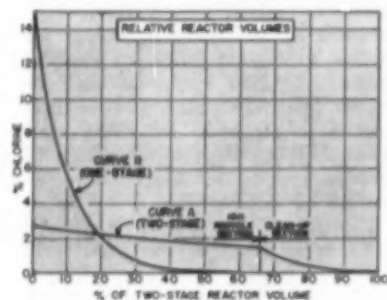


Fig. 8. Comparison of effects obtained in typical two-stage reactor.

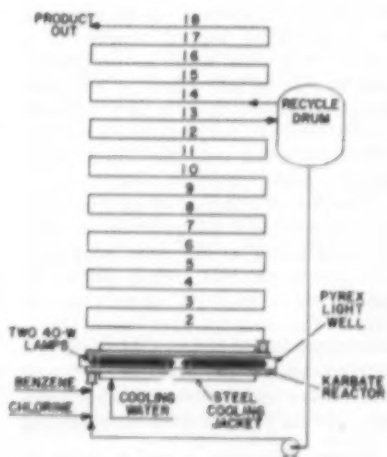


Fig. 9. Two-stage BHC photochemical reactor.

From recent developments in the field of fermentation
is assembled this new approach to the

process design of aeration systems for BIOLOGICAL WASTE TREATMENT

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The design of aeration systems for specific organic wastes requires that the mechanics of aeration and oxygen transport and the various physical and chemical factors which influence them should be established. Oxygen consumption by the biological process for various anticipated conditions must be known. Aeration equipment must be selected to satisfy these process requirements at an economic level. This paper presents an approach to the design of aeration systems for biological industrial waste treatment.

Theoretical concepts relating the variables affecting oxygen transfer in biological systems have been developed by Gaden (28) and others (29, 5). A review of the present state of knowledge has been made by Finn (1). A summary of these concepts is presented below.

In order to maintain maximum oxidative efficiency, aeration equipment must be designed to supply oxygen to a system at a rate equal to or greater than its rate of utilization. In activated sludge processes this is accomplished usually by oxygen diffused from air bubbles injected into the liquid-sludge mixture under turbulent conditions.

The rate of diffusion of oxygen from air bubbles into a sludge-liquid mixture is proportional to the interfacial area for transfer per unit volume and to the concentration level of oxygen in the liquid. The mass transfer rate is therefore equal to the product of the liquid film coefficient, the transfer area per unit volume and the concentration gradient. Owing to difficulties in measuring

interfacial areas, an over-all transfer coefficient, K_La is usually employed (1)

$$\frac{dc}{dt} = K_La(C_s - C_1) \quad (1)$$

K_La is a function of the bubble size and interfacial area, volume of liquid, the time of contact of air with liquid, tank depth, agitation intensity, and other physical and chemical variables characteristic of the system. High values of K_La are indicative of efficient aeration.

In a biological oxidation system such as the activated sludge process, oxygen is being removed from solution by the active microbial mass. The change in oxygen content of the system may therefore be expressed:

$$\frac{dc}{dt} = K_La(C_s - C_1) - K_rS_a \quad (2)$$

Normal biological waste treatment plant operation approaches a steady-state condition where the dissolved oxygen level in the aeration tanks is maintained substantially constant and Equation (2) may be expressed:

$$K_La(C_s - C_1) = K_rS_a \quad (3)$$

Equation (3) indicates that the factors which must be considered for aeration design are the saturation characteristics of oxygen in the particular waste as defined by C_s , the gas-liquid transfer properties of the waste to be aerated as defined by K_La , the oxygen utilization characteristics of the liquid-sludge mass as defined by K_rS_a , the oxygen absorption properties of particular aeration equipment, and the power requirements of the process under study.

Oxygen Saturation

Oxygen is a sparingly soluble gas in pure water, having a saturation at 20° C. of only 9.17 p.p.m. in equilibrium with the atmosphere. While the solubility is almost independent of the total pressure and the presence of other gases, it is directly proportional to the partial pressure of oxygen in the gas phase. If the partial pressure of oxygen in the gas phase is raised, the available concentration gradient or driving force for mass transfer can be increased. The oxygen utilization characteristics of the sludge are seemingly unaffected by higher oxygen tensions (2).

The saturation concentration of oxygen is influenced by partial pressure, temperature, and the presence of dissolved and other solids. Since air is usually released at a 12- to 15-ft. depth in waste oxidation practice, its partial pressure is influenced by the increased pressure of the entering air. As the air bubbles rise through the tank, oxygen is absorbed. This reduces the oxygen concentration in the gas phase. The effect of these factors must be considered in deriving a mean saturation value.

Table 1.—Gas Rate Exponent

| Aerating Device | n | Literature Cited |
|--------------------------------|------|------------------|
| Single bubble nozzle | 0.93 | (5) |
| Impingement unit | 0.80 | (15) |
| Grade 60 aloxite tubes | 0.85 | (15) |
| Alaxite plates | 0.78 | (12) |
| Colaflex diffuser | 0.56 | (16) |
| Porous sparger | 0.74 | (1) |

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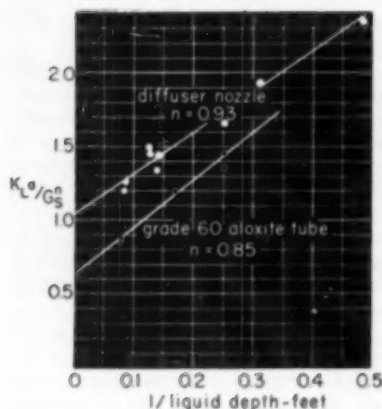


Fig. 1. Relation between oxygen transfer coefficient, air flow, and liquid depth.

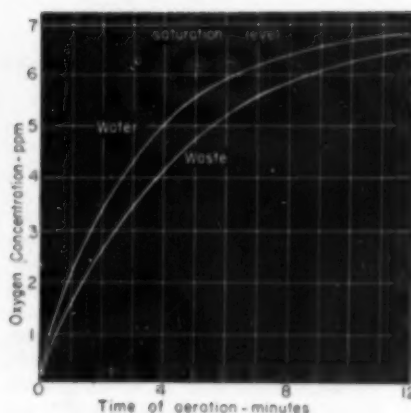


Fig. 2. Comparative oxygen transfer efficiency of water and a paper mill waste.



Diffuser spargers in sewage treatment aeration.

It may be anticipated that oxygen saturation will deviate from pure water in wastes of variable composition. For example, oxygen saturation in sewage is approximately 95% that of pure water (3). Various waste streams from pulp and paper manufacture have shown variations of 85 to 95% of pure water saturation.

Since many wastes must be treated at temperatures in considerable excess of the prevailing ambient temperature, a reduced gradient is available for transfer.

Saturation characteristics may be measured polarographically or chemically on well-aerated waste samples.

The oxygen saturation C_s for any particular waste oxidation system may be computed:

$$C_s = fC^* \left(\frac{P_b}{29.4} + \frac{O_2}{42} \right) \quad (4)$$

The effect of water-vapor pressure is neglected in Equation (4). While the mean gradient for rising air bubbles is defined by Equation (4), the gradient for surface aeration will be defined by C_s at atmospheric conditions and the gradient during interface formation by the partial pressure at the diffuser outlet. For practical purposes it is assumed these factors produce a compensatory effect.

Oxygen Transfer

Aeration characteristics are defined by $K_L a$ which is the product of the liquid film coefficient K_L and the ratio of interfacial area to volume of liquid under aeration. The available interfacial area depends upon the mean diam-

eter of the air bubbles in the tank, the air flow, and the tank depth. For most conventional diffusion devices, the bubble diameter will vary from 2 to 5 mm. Over this range the bubble velocity through water is approximately 0.75 ft./sec. Tank liquid circulating velocities in current practice range from 2 to 5 ft./sec.

EFFECT OF AIR RATE ON $K_L a$

At the air flow rates usually employed, the volume of individual bubbles increases with increasing flow rate whereas the frequency of individual bubble formation remains almost constant. Bubble coalescence and turbulence increase with gas rate. For any diffusion system under defined conditions a general relationship may be empirically derived

$$K_L a = C G_s^n \quad (5)$$

The exponent n has been experimentally evaluated for various diffusion devices. For a wide range of bubble fineness and dispersion Hixon and Gaden (4) showed a range of 0.33 to 0.82. Their conclusions showed that while fine bubble dispersers produce higher transfer at low air rates because of a larger interfacial area, this advantage is lost at increased air rates owing to the higher turbulence produced by the large bubble spargers. Some typical values of the exponent n for various devices are shown in Table I.

Use of Equation (5) neglects effects from variable tank geometry and hydraulics which may produce high tank circulating velocities. The increased turbulence will carry bubbles across the tank and down with the flow, this action increasing the holdup.

EFFECT OF TANK DEPTH ON $K_L a$

Oxygen absorption in diffused air aeration is assumed to occur in three phases (5). A large portion of oxygen solution occurs during bubble formation when the interface is created. In a 4-ft. depth tank Kountz (6) showed as much as 80% of the total absorption to occur during interfacial formation. As the bubble rises through the tank liquid a constant rate of transfer occurs across the interface. Scouller and Watson (7) found a liquid film coefficient K_L of 130 cm./hr. during bubble rise. Kountz (6) showed that only 20% of the total absorption occurred during bubble rise in a 4-ft. tank. In terms of over-all absorption efficiency, this is equivalent to an increase of 6 to 12%/ft. of rise through the tank liquid. This over-all rate will vary inversely as the bubble diameter. The bursting of the bubble at the surface and surface turbulence will produce additional absorption. Streeter, *et al.*, (8) related atmospheric reaeration at the surface to an exponential function of the surface fluid velocity.

Since the first and final phases of absorption yield higher transfer rates than occur during bubble rise and are virtually independent of depth within practical limitations, $K_L a$ must decrease with increasing tank depth. This relationship is defined by Equation (6).

$$K_L a = C(C/D + 1) \quad (6)$$

Equations (5) and (6) can be combined to give a general relationship between gas flow, depth, and $K_L a$.

$$K_L a = C^{11} G_s^n (C^1/D + 1) \quad (7)$$

This relationship for two diffusion devices is shown on Figure 1.

Table 2.—Observed Respiration Rates in Biological Oxidation Systems

| Waste | Respiration | Rate mg. O ₂ /hr./g. sludge | Literature Cited |
|----------------|-------------|---|---------------------|
| Sewage | active | 10-20 | (20-22) |
| Sewage | endogenous | 1.85-9.8 | (20) |
| Dairy | active | 40-45 | (23) |
| Dairy | endogenous | 4-10 | (23) |
| Cannery | active | 35 | (24) |
| Pharmaceutical | active | 76 (avg. max. recorded) | (25) |
| Pulp and paper | active | 10-15 | (26) |

EFFECT OF TEMPERATURE ON K_La

K_La will be affected by changes in operating temperature due to its effect on the diffusivity of oxygen in water. The Stokes-Einstein equation has been modified by O'Connor (9) to define the effect on temperature on K_La

$$\frac{K_{La}(T_1)}{K_{La}(T_2)} = \sqrt{\frac{T_1\mu_2}{T_2\mu_1}} \quad (8)$$

Equation (8) may be employed to correct K_La at one operating temperature to another temperature.

EFFECT OF WASTE CONSTITUENTS

Wastes will exhibit variable capacity for mass transfer under defined aerating conditions. Certain constituents in a waste may reduce the mass transfer rate to as low as 10 to 20% of that attainable in pure water. A concentration of 50 p.p.m. of certain anionic detergents will reduce the transfer rate to 50% that of water (10). This reduction in K_La has been attributed to reduced shear at the bubble boundary and a slower rate of bubble rise through the liquid (5). As high as 60% reduction in transfer rate can be expected in the presence of anti-foam agents (11). Extensive studies by King (12) showed the transfer coefficient for fresh sewage to be only 26 to 46% of water and septic sewage 16 to 19% water. Oxygen transfer studies on pulp and paper mill wastes showed a variation in K_La of 60 to 120% of water for several mill effluents.

The transfer characteristics will also vary over the course of the oxidation cycle owing to chemical and physical changes in the substrates (4). In the treatment of domestic sewage, 4-hr. aeration with activated sludge increased the transfer coefficient from 68 to 73% to 76 to 100% of water. Treatment of a Kraft mill waste resulted in an increase from 45 to 79% of water after three hours' aeration with activated sludge. This variation is probably due principally to changes in the interfacial area per unit volume. Observations of the aeration of sewage and wastes show transitions in the nature of air dispersion as the oxidation proceeds. Most systems go through a nonfoaming fol-

lowed by a foaming phase, finally followed by no foaming as the oxidation process approaches completion. Since most available data on aeration equipment performance is based on mass transfer characteristics in pure water or sulfite solution, design data should include transfer rates in wastes relative to pure water as defined by the coefficient α .

Such data may be obtained by non-steady-state aeration under standardized conditions (5) or by comparative sulfite oxidation tests (13).

In the former procedure metered air is diffused into a measured volume of waste initially deaerated with nitrogen.

The dissolved oxygen content is measured at selected time intervals. Usually, readings need be made only to 90% of saturation. A transfer plot can be obtained over a 5- to 10-min. sampling cycle applying 0.1 to 0.2 cu.ft./hr. of air to a liter graduate of waste through an Aloxite diffuser stone. The transfer coefficient K_La can be computed from the slope of an exponential plot of $(C_s - C_1)$ vs. time of aeration. Comparison of the transfer coefficients for particular wastes with water will be indicative of the relative efficiency of aeration. A comparative plot of transfer characteristics for pure water and a paper mill effluent is shown on Figure 2.

Transfer rate characteristics may be compared also by sulfite oxidation. Air is admitted to samples of water and waste approximately 0.2 N in sulfite ion. Copper or cobalt should be added as a catalyst. Unoxidized sulfite ion is measured at selected time intervals by iodometric titration. The slope of the sulfite-time curve will reveal the oxygen absorption rate. King (12) showed computed coefficients from sulfite oxidation to be higher than water. Comparative studies on several wastes revealed favorable relative comparisons between sulfite oxidation and the nonsteady-state data.

Oxygen Utilization

Oxygen utilization may be defined as the weight of oxygen consumed per unit weight of biological sludge per unit of time. It is usually expressed as mg.

O₂/hr./g. sludge. The total oxygen uptake rate in a system will be the product of the unit rate and the sludge concentration carried in the aeration tanks. Over the range of sludge concentrations usually employed, this relationship will be linear.

The uptake rate characteristics will vary as the sludge passes through various growth stages. The rate can be generally considered in two phases; active respiration which occurs in the presence of nutrients and is characteristic of a growing sludge, and endogenous respiration which is the autooxidation of cellular tissue. The endogenous respiration rate is 5 to 10% of the active respiration rate.

The oxygen consumed during active respiration can be directly related to the B.O.D. removed in the aeration system per unit time (14). The endogenous respiration is usually expressed as a percent per day of the volatile sludge solids under aeration. In practice, this rate will decrease with time since various cellular constituents differ in case of oxidation.

The total oxygen requirements for a biological system may therefore be related to the quantity of organic matter removed and the concentration of sludge solids under aeration according to Equation (10).

$$\text{lb. O}_2/\text{day} = a \text{ lb. B.O.D. removed/day} + b \text{ lb. M.L.V.S. (mixed liquor volatile solids)} \quad (10)$$

The constants a and b for this relationship must be experimentally evaluated for any particular waste oxidation system. A typical relationship for a pulp and paper oxidation is shown in Figure 3. The oxygen utilization rate characteristics for various waste oxidation systems are shown in Table 2.

The utilization rate for prototype design can be computed from Equation (10) or estimated from a statistical analysis of rate data under anticipated loading conditions. These data are obtained from laboratory or pilot plant studies.

In the long rectangular aeration tanks used in conventional activated sludge practice, the sludge-liquid mixture is rolled down the tank length with a spiral motion imparted by the air. As the B.O.D. in the influent waste undergoes oxidation and synthesis, the oxygen utilization rate decreases approaching the endogenous level. This level is approached toward the end of the aeration basins. The mean utilization rate is defined by the B.O.D. removed and the mixed liquor suspended solids carried in the aeration tanks as shown by Equation (10). The utilization rate at any point in the aeration tanks may be related to

time of aeration or tank length (see Figure 4). The endogenous respiration level can be estimated by the extrapolation of the rate curve to a zero removal level as shown on Figure 3.

In order to take economic advantage of this decreasing utilization rate through the aeration tanks, tapered aeration can be employed. $K_L a$ can be adjusted to meet the necessary demand by increasing or reducing the number of individual aeration assemblies along the tank length, or the air rate can be regulated at each point in the aerator by appropriate valving. In the derivation of a tapered aeration design the variation in $K_L a$ with oxidation must be considered. The value of $K_L a$ relative to water, α , will increase with oxidation.

A tapered utilization rate will usually not be found when square or circular tanks are employed. The homogenizing effect of the agitation and aeration will tend to equalize the utilization rate at the mean level.

The oxygen utilization rate can be measured by the direct absorption of gaseous or dissolved oxygen wherein oxygen utilization is determined by a variation in gas volume or pressure. Typical examples are the Sierp and Warburg assemblies.

The polarographic analysis may be used in which the decrease in oxygen concentration in a near-saturated sludge sample is measured at one-half or one-minute intervals. The utilization rate is the slope of the concentration-time curve. The utilization rate can be determined usually in five minutes or less, which renders this method especially suitable for plant operation and control testing.

Use of the oxygen gas analyzer for utilization rates offers the advantage of analysis under plant operating conditions. This will more closely approximate a true value since turbulence and other system characteristics, which will influence the magnitude of the uptake rate, are considered in this analysis.

In many waste systems where the respiratory quotient of the sludge is approximately 1.0, the rate of CO_2 output of the sludge can be used as parameter of oxygen consumption.

Aeration Equipment

The success of an aeration system to perform according to design will depend upon the ability of the aeration equipment to supply the requisite quantity of oxygen.

There are three basic types of aeration devices commercially available:

(a) small orifice diffusion units such as porous media, plates, or tubes constructed of silicon dioxide or aluminum oxide grains held in a porous mass with a ceramic binder. Competitive units include saran- or nylon-wrapped tubes or bags. These units may be permanently placed in the bottom of an aeration tank or suspended from flexible joints along the sidewall of a tank. When air is diffused through these units, a helical or screw motion is imparted to the sludge-liquid mixture. A minimum air flow must be employed to prevent deposition of sludge solids on the tank bottom. High maintenance costs may be encountered in some waste applications due to orifice clogging, etc.

(b) units employing a mechanical or air shear such as the impingement or jet aerator. The jet aerator pumps liquid from the aeration tanks through a piping manifold. The unit aspirates and disperses atmospheric air or air from a blower within the capacity of the ejector. Power consumption is a consideration since the liquid is circulated at 25 to 30 lb./sq.in. pressure. Orifice clogging problems may result in certain applications.

The impingement aerator employs a water stream air lifted from the aeration tanks as a shearing device for air bubbles discharged from a large orifice. The control variables are the impingement

liquor flow, air flow, and the location of the water nozzle relative to the air orifice. The necessity for air filters is usually eliminated.

(c) mechanical aerators which entrain atmospheric oxygen into the sludge by surface agitation, or disperse compressed air by a shearing and pumping action employing a rotating turbine or agitator. In the latter unit, air bubbles are discharged from a pipe or sparge ring beneath the agitator and are broken up by the shearing action of the high-speed rotating blades of the agitator moving through the liquid. The relative effect of liquid pumping and air shear depends upon the size of the agitator with respect to the tank. For systems of low-oxygen utilization rate, oxygen may be supplied by air self-induced from a negative head produced by the rotor. This eliminates the necessity for external blowers or compressors.

Diffused Aeration Performance

The performance of air diffusion devices depends upon the characteristics of the air bubbles produced and the turbulence generated in the system. Kountz (6) showed that the creation of a square foot of interfacial area involves the same energy regardless of the aerating device employed and he also illustrated that any power in excess of this is consumed for mixing. The oxygen transfer and power characteristics of various aeration equipment derived from sulfite oxidation studies are shown in Table 3. Table 4 gives field data from several waste systems.

Aeration tanks normally designed for biological oxidation employing air dif-

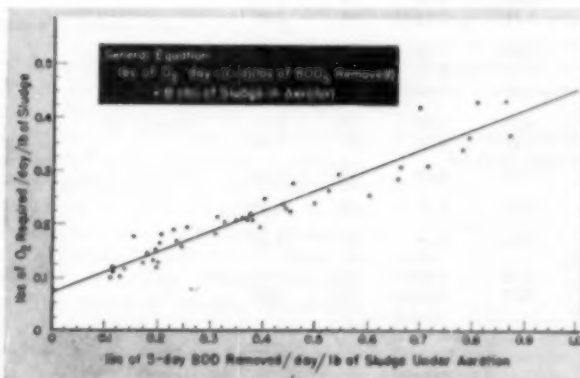


Fig. 3. Relation between oxygen consumed and B.O.D. removal for a paper mill waste.

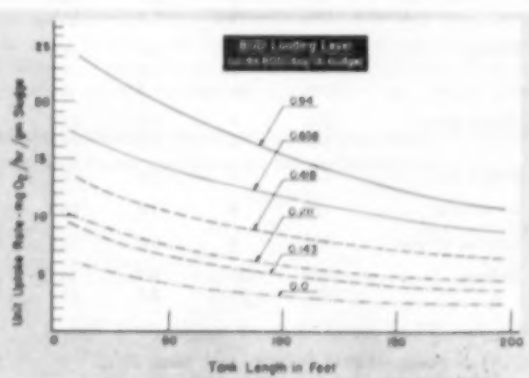


Fig. 4. Variation in utilization rate with aeration tank length and B.O.D. loading level.

usion units vary in depth from 10 to 15 ft. The maximum width to depth ratio to insure adequate circulation is 2:1. Diffusion units are generally placed 2 ft. above the floor of the aeration tank.

The impingement-type aerator is usually installed in headers up to 40 ft. in length with impinger bowls and water nozzles saddle mounted to the air and water headers on 15- to 24-in. centers. Each unit is designed to diffuse 4 to 16 cu.ft./min. air with an impinger liquor flow of 15 to 20 gal./min. The bubble size released depends on the quantity of impingement liquor flow delivered by the circulating air-lift pump. Absorption increases linearly with impingement liquor flow over the range normally employed in practice. The power required for pumping impingement liquor is 8 to 15% of the total power for aeration. Over the normal operating range transfer efficiencies of 10 to 12% can be expected based on sulfite oxidation tests (15).

Standard porous diffuser units are designed to deliver 4 to 8 cu.ft./min./unit. The absorption efficiency depends on the size of air bubbles released; this in turn depends on the type and porosity of diffuser unit. King (12) has shown the bubble diameter to vary from 2.5 to 3.8 mm. for 40 to 80 porosity tubes or plates. By the use of the 60 porosity tube as a base, a 40 porosity unit will be 115% as efficient and, an 80 porosity unit 85% as efficient.

In order to maintain adequate circu-

lating velocities, a minimum air flow of 3 cu.ft./min./lineal foot of tank must be maintained. The minimum spacing of units is 6 in. and the maximum spacing 2 ft.

Diffuser plates, designed to cover 5 to 10% of the tank area, are usually placed along one side of the bottom of an aeration tank.

A wide range of oxygen absorption, depending upon the selection of operating variables, can be obtained with the jet aerator. Studies by Kountz (6) showed that the rate of dissolved oxygen supplied is a function of the nozzle stream surface velocity as is also the air volume aspirated. For various units 0.66 to 1.0 lb. O₂/hr. can be transferred at liquid pumping rates of 34 to 44 gal./min. These values can be increased by about 50% by supplying additional air with a blower. An 18.3 to 20.1% absorption has been reported by Hauer in sulfite oxidation (27).

Other diffusion units operating under similar principles include the Colaflex diffuser and the Diffusair assembly.

Mechanical Aeration Performance

The turbine aerator finds principal application in the treatment of high B.O.D. industrial wastes. While the absorption limit of most diffused aeration units is 150 lb. O₂/day/1,000 cu.ft., mechanical aerators can disperse as much as 600 lb. O₂/day/1,000 cu.ft.

In the turbine unit air is discharged from a large diameter orifice beneath

the rotating blades of an impeller. As the speed of the impeller is increased, the bubble size is decreased and the holdup increased, thus the total interfacial area is increased. Bubble diameter has been shown to vary inversely as the three-halves power of the peripheral speed (17). As the bubbles rise away from the impeller, the mean diameter increases owing to coalescence.

Oxygen absorption in the turbine aerator will be a function of the air flow rate and the power input to the rotating agitator. A general relationship can be expressed by the formula

$$K_L a \sim V_s^{0.75} (\text{hp.})^0 \quad (11)$$

With gas flow rate expressed as superficial gas velocity, V_s , is convenient in turbine design since V_s is independent of tank size for geometrically similar impellers and vessels.

Data obtained on sewage oxidation in a 3-ft. square tank with a 3-ft. liquid depth and 4-in. diam. impellers are shown on Figure 5. The exponents x and y in Equation (11) have been evaluated for several systems and are shown in Table 5.

Other formulations have shown the oxygen-transfer efficiency to be directly proportional to the three-halves power of the peripheral velocity and inversely proportional to the square root of the ratio of the total air flow to the peripheral area (18). Relating air flow to peripheral area is functionally similar to employing the superficial gas velocity

Table 3.—Oxygen Transfer and Power Characteristics of Aeration Equipment

| SULFITE OXIDATION DATA ^a | | | | | | | | | | |
|-------------------------------------|--------------------|--|------------------|-----------------------------------|-----------------------------|-----------------------------------|----------------|-----------|--------------------------------|--------------------------|
| Unit | Volume unit cu.ft. | Air rate ¹ std.cu.ft./min. unit | K _L a | Oxygen ² transfer eff. | lb.O ₂ /hr./unit | lb.O ₂ /hr./1,000 gal. | Hp./1,000 gal. | Depth ft. | Kw.hr./lb. O ₂ abs. | Equipment |
| 1. Impingement | 300 | 4 | 3.3 | 15.2 | 0.63 | 0.28 | 0.08 | 15 | 0.21 | 18 gal./min. liquor flow |
| | 300 | 6.3 | 3.5 | 10.7 | 0.70 | 0.31 | 0.13 | 15 | 0.31 | " " " " " |
| | 300 | 8 | 4.7 | 10.9 | 0.91 | 0.41 | 0.16 | 15 | 0.29 | " " " " " |
| | 300 | 12.6 | 7.5 | 11.5 | 1.51 | 0.51 | 0.25 | 15 | 0.28 | " " " " " |
| 2. Diffusair | 160 | 4 | 2.8 | 6.8 | 0.28 | 0.24 | 0.08 | 8 | 0.25 | |
| | 160 | 8 | 4.2 | 5.2 | 0.43 | 0.36 | 0.16 | 8 | 0.33 | |
| | 160 | 16 | 9.3 | 5.8 | 0.96 | 0.80 | 0.32 | 8 | 0.30 | |
| 3. Aloxite tubes | 300 | 4 | 2.8 | 13.5 | 0.56 | 0.26 | 0.07 | 15 | 0.20 | porosity 60 |
| | 300 | 8 | 5.1 | 12.1 | 1.00 | 0.37 | 0.14 | 15 | 0.28 | |
| 4. Drilled pipe | 240 | 4 | 1.5 | 5.1 | 0.23 | 0.13 | 0.08 | 12 | 0.46 | 15 1/2-in. holes |
| 5. Jet aerator | 100 | 4 | 11.0 | 14.0 | 0.63 | 0.84 | 0.60 | 5 | 0.53 | |
| 6. Colaflex diffuser .. | 240 | 4 | 3.0 | 10.5 | 0.47 | 0.26 | 0.08 | 12 | 0.23 | |
| 7. Turbine | 3800 | 180 | 8.7 | 10 | 20.3 | 0.72 | 0.32 | 12 | 0.33 | |
| | 3800 | 72 | 8.7 | 25 | 20.3 | 0.72 | 0.37 | 12 | 0.38 | |

Notes: Nos. 1-3 all placed 18 in. off aeration basin floor.

¹ air density—0.0746 lb./cu.ft.; tank temp. 20° C.

² zero oxygen level in aeration tanks

³ data of Dreier (15) and Kountz (6).

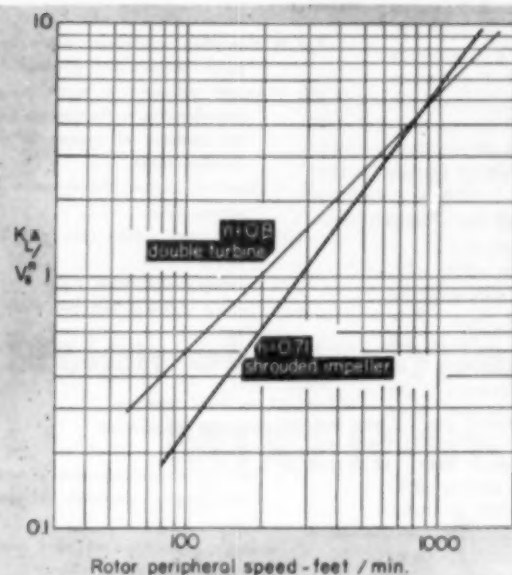


Fig. 5. Oxygen transfer characteristics of turbine aerators in sewage oxidation at 3-ft. liquid depth.

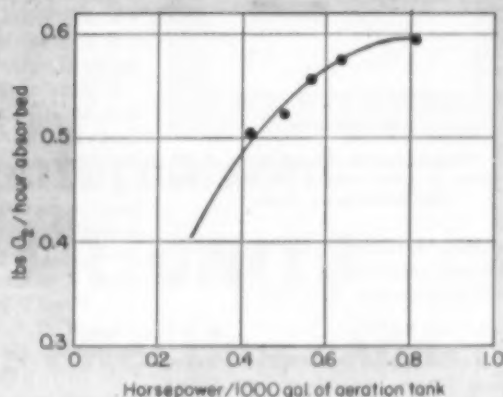


Fig. 6. Relation between power absorbed and oxygen utilization in sewage oxidation.

Table 4.—Operating Data for Various Waste Applications

| Unit | Waste | Temp. ° C. | Depth ft. | Air flow std.cu.ft./min. unit | r_s p.p.m./hr. | σ_L p.p.m. | $K_L a$ | Eff. | | lb. O ₂ /hr. unit | lb. O ₂ /hr. 1,000 gal. |
|---------------------|--------|---------------|--------------|-------------------------------------|---------------------|----------------------|---------|-----------------|--|---------------------------------|---------------------------------------|
| | | | | | | | | % max. grad. | | | |
| 1. Colaflex | sewage | 17 | 12 | 5 | 14.6 | 3.6 | 2.11 | 5.5 | | 0.38 | 0.18 |
| 2. Impingement . . | paper | 36 | 15 | 11.4 | 30.0 | 1.63 | 4.89 | 9.4 | | 1.12 | 0.31 |
| 3. Drilled pipe . . | paper | 33 | 12 | — | 13.9 | 2.3 | 2.6 | 2.3 | | — | 0.17 |
| 4. Jet | dairy | 25 | 16.5 | 17 | 18.5 | 4.15 | 3.4 | 6.4 | | 1.12 | 0.27 |
| 5. Saran tubes . . | sewage | 23 | 15 | 12.3 | 40.0 | 1.5 | 5.0 | 6.2 | | 1.32 | 0.667 |

V_s . Since the proportion of power input to the agitator and air source is varied, oxygen transfer efficiencies of 10 to 50% can be attained. This will result in a variation in power of 0.25 to 0.5 kw.-hr./lb. O₂ absorbed. The maximum air flow to an agitator has been reported as 15 to 20 cu.ft./min./sq.ft. of peripheral area (18).

Power Requirements

When the concentration of dissolved oxygen in solution exceeds 0.2 to 0.5 p.p.m., the rate of microbial respiration is independent of oxygen concentration. Below this level respiration is retarded due to unsaturation of the oxygen enzyme systems (4). In addition to the maintenance of oxygen levels in excess of the critical level, power must be supplied for mixing. Sludge cells tend to clump, hence to decrease the quantity of oxygen which can be transferred to them. The rate of oxygen diffusion into the sludge is related to floc size, diffusivity, oxygen utilization rate, and the oxygen concentration level in the liquid.

Increased power levels will disperse the sludge and increase the transfer rate. For average sewage oxidation maximum oxygen penetration will occur when the unit sludge radius does not exceed 100 to 200 μ (20). The effect of power level on oxygen utilization rate for a sewage oxidation system is shown on Figure 6.

The power level is limited, however, by the necessity to avoid excessive floc shearing for subsequent solid-liquid separation. With turbine aerators in the aero-accelerator unit, Kalinske (18) showed the maximum peripheral speed

as 10 ft./sec. Other studies (20), depending upon the characteristics of the sludge in the system, have shown the maximum power level to be approximately 0.7 hp./1,000 gal.

Aeration Design

For practical design considerations it may be assumed that the quantity of oxygen transferred per unit time by an air diffusion unit within the critical area of air dispersion is a function of depth, temperature, gas flow, and waste char-

Table 5.—Gas Absorption and Power Relationships for Mechanical Aerators

| System | Exponent | | Literature Cited |
|-------------------------|----------|------|------------------|
| | x | y | |
| Sulfite | 0.8 | 0.8 | (11) |
| Sulfite | 0.67 | 0.95 | (13) |
| Sewage | 0.80 | 1.54 | A |
| Sewage | 0.71 | 1.10 | A |
| Dairy waste | 0.39 | 0.54 | (11) |
| Cannery waste | 0.70 | — | A |
| Sewage | 0.83 | — | A |

A—author's unpublished data.

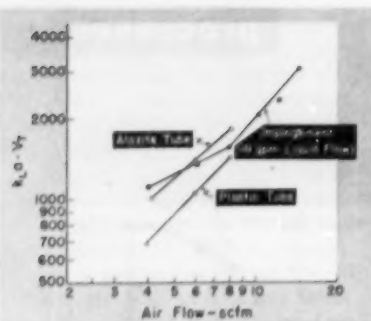


Fig. 7. Oxygen transfer characteristics of diffuser units in sulfite solution at 20°C. and 13-ft. submergence depth.

acteristics. Equation (12) provides a convenient relationship for design at specific temperature and depth

$$K_L a = C G_a^n \cdot 1/V_T \quad (12)$$

In gas absorption systems employing turbines, Cooper, Fernstrom, and Miller (13) employed an absorption number $K_L a/V_T$. The transfer characteristics of diffusion units at specified depths may be similarly related by the absorption number $K_L a V_T / G_a^n$.

Data for various diffusion units derived from sulfite oxidation at 20°C. are shown in Figure 7.

In diffused aeration systems $K_L a$ may be varied by the following:

(a) unit-spacing selection—minimum spacing is limited by interfering air-diffusion patterns and maximum spacing by that necessary to maintain adequate tank-circulating velocities.

(b) bubble size—bubble size in porous diffuser units depends on permeability and in the impingement-type unit on the circulating liquor flow.

(c) air flow—the limiting range of air flow for most units is 4 to 8 cu.ft./min./unit.

In turbine aerators $K_L a$ may be varied by either the impeller speed or the air flow.

A suggested design procedure for aeration systems in biological oxidation processes is outlined below:

1. Compute the oxygen saturation characteristics, C_a , at process operating temperatures and pressure for the particular waste to be treated according to Equation (1).

2. The minimum operating dissolved oxygen level should be maintained between 0.5 and 1.0 p.p.m. to insure aerobic action.

3. The B.O.D. removal requirements are usually established by stream conditions or state standards. Aeration requirements and biological solids level in the aeration tanks are defined by laboratory or pilot plant studies. The unit oxygen uptake rate for various B.O.D. removal levels can be estimated from an experimental plot such as Figure 3.

4. The oxygen demand distribution will be a function of time of aeration. This may be obtained by a laboratory study. The actual demand distribution in the aeration tanks will depend on the hydraulic characteristics of the particular tanks as designed. A load distribution curve such as illustrated by Figure 4 is employed.

5. $K_L a$ for each section of the system can be computed from Equation (3).

6. Aerator performance in sulfite solution at 20°C. and 13-ft. submergence depth can be obtained from Figure 7 or from data similarly derived. The operating $K_L a$ derived from Equation (3) must be corrected for temperature if the operating temperature deviates from 20°C. and for the oxygen-transfer coefficient, a , of the specific waste.

7. From Figure 7 (or a similar plot) the unit air flow-volume factor to transfer the required oxygen is selected.

8. After a tank width and an air flow/unit has been selected, the unit spacing is computed.

9. This should establish the design for the most severe operating conditions. Under less severe conditions (winter operation, lower B.O.D. loadings, etc.), the reduced required air flow can be computed in a similar manner.

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Literature Cited

1. Finn, R. K., *Bact. Reviews*, **18**, 4 (December, 1954).
2. Okun, D., and W. Lynn, *Proc. Bio. Waste Treatment Conf., Manhattan College* (April, 1955).
3. Moore, E., *Sewage Works J.*, **16**, 473 (August, 1937).
4. Nixon, A. W., and E. L. Gaden, Jr., *Ind. Eng. Chem.*, **42**, 1792 (1950).
5. Ippen, A. T., and E. Carver, *Sewage Ind. Wastes*, **26**, 813, (July, 1954).
6. Kountz, R. R., *Proc. Bio. Waste Treatment Conf., Manhattan College* (1955).
7. Scouller, W. D., and W. Watson, *J. Inst. Sew. Purif. Part 1*, 123, (1934).
8. Streeter, H. W., C. T. Wright, and R. W. Kehr, *Sewage Works J.*, **8**, 282, (February, 1936).
9. O'Connor, D. J., D.Sc. Thesis, New York University (1955).
10. Sawyer, C. N., and W. O. Lynch, *Sewage Ind. Wastes*, **26**, 1193, (October, 1954).
11. Oldshue, J. Y., *Proc. Tenth Ind. Waste Conf., Purdue University* (1955).
12. King, H. R., *Sewage Ind. Wastes*, **27**, 894 (August, 1955).
13. Cooper, C. M., G. A. Fernstrom, and S. A. Miller, *Ind. Eng. Chem.*, **36**, 503 (1944).
14. Eckenfelder, W. W., and R. F. Weston, *Proc. Bio. Waste Treatment Conf., Manhattan College* (1955).
15. Dreier, D. E., *Proc. Bio. Waste Treatment Conf., Manhattan College* (1955).
16. Eckenfelder, W. W., Unpublished data.
17. Vermeulen, T., G. M. Williams and G. E. Langlois, *Chem. Eng. Progr.*, **51**, 85-F (February, 1955).
18. Kalinske, A. A., *Proc. Bio. Waste Treatment Conf., Manhattan College* (1955).
19. Pasveer, A., *Sewage Ind. Wastes*, **26**, 28, (January, 1954).
20. Sawyer, C. N., *Sewage Works J.*, **10**, 662 (March, 1939).
21. Sawyer, C. N., *Sewage Works J.*, **10**, 661, (April, 1938).
22. Grant, S., E. Hurwitz, and F. W. Mohlman, *Sewage Works J.*, **2**, 228, (February, 1930).
23. Hoover, S. R., *Sewage Ind. Wastes J.*, **23**, 2, (February, 1951).
24. Eckenfelder, W. W. and E. Grich, *Proc. Tenth Ind. Waste Conf., Purdue University* (1955).
25. Dryden, F. E., et al, *Proc. Tenth Ind. Waste Conf., Purdue University* (1955).
26. Eckenfelder, W. W. and T. L. Moore, *Eng. News Record* (December 6, 1954).
27. Hauer, G. E., *Proc. Ninth Ind. Waste Conf., Purdue University* (1954).
28. Gaden, E. L. Jr., *Proc. Bio. Waste Treatment Conf., Manhattan College* (1955).

Notation

- $K_L a$ = absorption coefficient, p.p.m./hr./p.p.m. concentration gradient
- C_a = oxygen saturation in waste, p.p.m. corresponding to the average partial pressure of oxygen in the aeration tanks
- C_i = dissolved oxygen concentration in waste, p.p.m.
- K_r = unit oxygen uptake rate, mg. O₂/hr./g. sludge
- S_a = aeration sludge solids, p.p.m.
- a = fraction of B.O.D. removed which is oxidized
- b = endogenous respiration, %/day
- C, C' , etc. = empirical constants
- T = absolute temperature
- μ = viscosity
- f = ratio of oxygen saturation in waste to oxygen saturation in pure water
- C^* = oxygen saturation of pure water under standard conditions
- P_a = pressure at diffuser discharge, lb./sq.in.abs.
- O_i = oxygen concentration of air leaving aeration tanks, %
- G_a = air flow to diffuser unit, std.cu.ft./min.
- V_T = volume of aeration tank occupied by one diffusion unit, cu.ft.
- a = ratio of $K_L a$ in waste to $K_L a$ in pure water
- V_s = superficial air velocity, ft./hr.

Box-type mixer-settler units, an economical and highly efficient type of countercurrent extractors, are becoming increasingly popular in the chemical industry both on a laboratory and a plant scale (2, 3, 4, 5). This paper describes a graphical method for designing these countercurrent extraction units with respect to flow capacity.

design of box-type, countercurrent MIXER-SETTLER UNITS

— factors affecting capacity

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Extraction in a cascade system of individual mixing chambers and settling chambers has economic disadvantages arising from the high cost of vessels, pumps, instrumentation, piping, and supporting structure. This shortcoming has been overcome by placing the extraction-decanting stages side by side, thus forming a boxlike unit consisting of several compartments. Fluid flow is promoted both by the density difference of the two liquids and also by the energy derived directly from the agitator.

The plan view of a typical three-stage mixer-settler unit is shown in Figure 1. The mixing and settling chambers are indicated by 2, 5, 8 and 3, 6, 9, respectively. Chambers 1, 4, 7 are impounding sections. Their primary purpose is to prevent the backflow from the mixing chambers from reaching the adjacent settling chambers. The lighter phase enters 1 and flows 2, 3, 4, 5, 6, 7, 8, 9, and out. The heavy phase enters 7 and flows 8, 9, 4, 5, 6, 1, 2, 3, and out. The broken lines indicate the interstage and intrastage flow ports. The flow of both liquids within a stage is cocurrent, whereas between stages it is countercurrent. For the sake of clarity, this three-stage unit is shown in Figure 2 with each stage in a single plane. Representation in this fashion necessitates showing

the heavy-phase flow between stages in external piping. In practice with the boxlike design, the heavy phase flows through the interstage ports in the chamber walls.

Three basic considerations in the design of mixer-settler units are:

- A. design for adequate mixing
- B. design for adequate settling
- C. design for desired throughput capacity

Principles governing the design of mixing and settling chambers have been widely published (1, 6-15). The design for desired throughput capacity is discussed below.

Flow Capacity

In the two extreme cases of no agitation and thorough agitation in the mixing sections, principles governing liquid flow through mixer-settler units are quite different. Conservative design practice is first to size the unit for the desired throughput in the case of zero agitation and then, by proper arrangement of baffles, equal or greater flows can be obtained with agitation.

CAPACITY WITH ZERO AGITATION

The layout elevation view shown in Figure 2 is used to aid in the presentation of the proposed procedure for calculating the throughput capacity of mixer-settler units. With no agitation, gravity flow is relied upon and levels in each chamber are dependent on levels in every other chamber. A quantitative mathematical analysis of the flows requires the solution of many simultaneous

equations of powers up to five (for a 3-stage unit) or a tedious trial-and-error calculation. The graphical method presented here greatly simplifies this calculation.

The relationship which exists between static pressure and liquid depth in each chamber is important for a qualitative understanding of the various factors affecting flow (Figure 3). For any given chamber, the pressure increases at a constant rate when going downward in one phase. At the interface there is a sudden change in slope as shown. The top liquid level falls between chambers (and stages) in the direction of flow (1 → 9) of the light phase. The liquid-liquid interface level also falls between stages in the direction of flow of the heavy phase. The change in interface level between chambers within a given stage, however, is not consistent, as shown, and will be discussed in detail. The pressure distribution shown (Figure 3) satisfies the qualitative requirements for gravity flow throughout the entire three-stage unit. The light phase will flow from 1 to 2, from 2 to 3, and then between stages from 3 to 4, and so on. The heavy phase, in turn, will flow from 4 to 5, 5 to 6, and then from 6 to 1, as required for countercurrent flow between stages.

The following assumptions were made in preparing the pressure gradient diagram.

- a. The only resistances to flow are in the ports, (i.e., the intrastage ports, *A* and *B*, and the interstage ports, *C* and *D*). This permits the expression of the pressure gradient within a given chamber by a single curve.

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The derivation of various equations relevant to this development is on file (Document 4873) with A.D.I. Auxiliary Publications Project, Library of Congress, Washington, D. C. Material obtainable by remitting \$1.25 for photoprints and \$1.25 for microfilm.

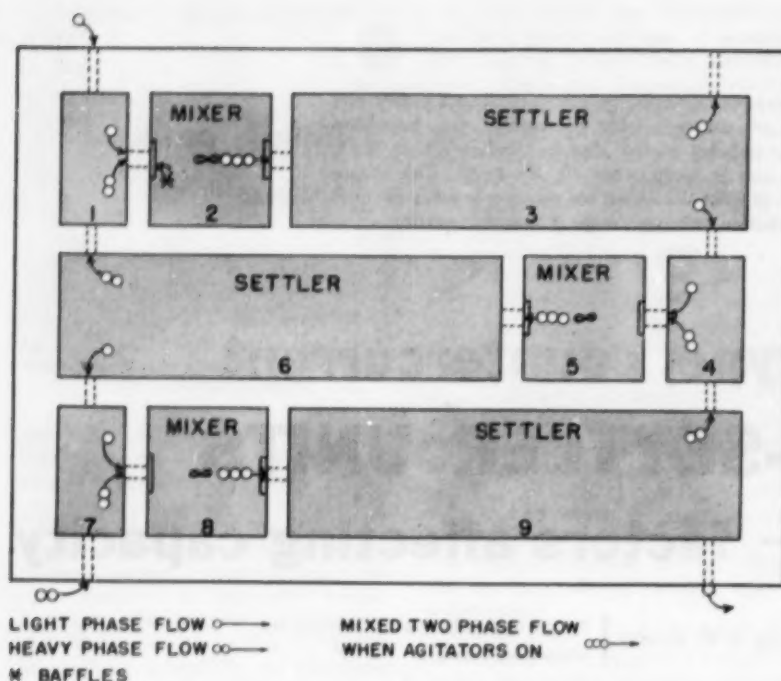


Fig. 1. Plan view of a three-stage mixer-settler unit.

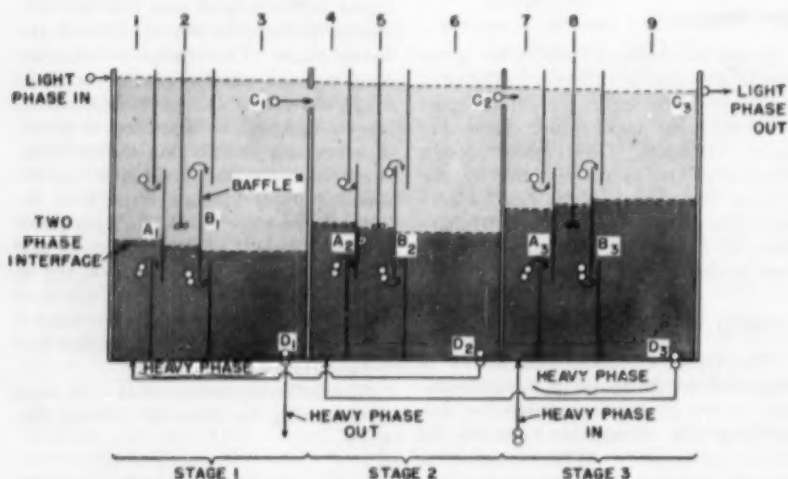
b. The density of each phase remains the same throughout the unit. Variations in density between stages will be discussed later.

An inspection of this pressure diagram shows that the maximum throughput for a mixer-settler unit will be determined by the over-all change in height of the top liquid level, causing the light phase to overflow the equipment in chamber 1 (Figure 2), or by the over-all increase in height of the interface, causing the heavy phase to flow out the light-phase exit port in chamber 9.

The graphical calculation presented here evaluates the change in interface level. However, the total change in the top liquid level can also be determined and should be allowed for in the design.

For the interstage ports (that is, between 3 and 4 for the light phase or between 6 and 1 for the heavy phase in Figure 2), only one phase is flowing and the pressure drop calculation is straightforward (11).

$$\Delta P = \frac{Kv^2}{2g} \quad (1)$$



NOTE: BAFFLES AT PORTS A AND B CLOSED ON SIDES AND OPEN AT TOP AND BOTTOM

Fig. 2. Unfolded elevation view of three-stage mixer-settler, agitators not operating.

For the intrastage ports (that is, between 1 and 2 or 2 and 3 in Figure 2), two phases, unmixed, are flowing through a center opening. The pressure drop calculations here are somewhat more complicated and a change in interface level normally occurs in going through the port.

In order to facilitate the calculations, the concept of the "normal" position of the interface must be introduced. The normal interface is defined as the interface position at the entrance to an intrastage port, which results in the same pressure drop across the port in each phase. This is essentially true, when the port area occupied by the flow of each phase is proportional to the relative volumes of each phase flowing. Under these conditions, the interface on the downstream side of the port is assumed to be at the same height as the height of the interface entering the port. The pressure diagram for this position is shown in Figure 4 (a).

When the entering interface level is caused to differ from the normal level, there will be an additional change in interface in going through the port. For example, if the entering interface is above the normal position due to conditions elsewhere in the unit, the pressure gradients shown in Figure 4 (b) will exist. The area for light-phase flow is at most between point I_1 (upstream interface) upward to the top of the hole. Because the area for flow of the light phase is less than that at the normal interface position, the velocity and consequently the pressure drop for flow of the light phase must be higher than that for the heavy phase (which has a larger relative area available for flow). Therefore, the interface level will rise in going through the port if the entering interface level is above the normal position.

The amount of this interface rise or fall can be evaluated in the following manner. A plot is introduced in which the pressure drop (ΔP) in a horizontal plane through a port is plotted against its (that is, the horizontal plane's) vertical position in the port. It is generally most convenient to represent this interface position as fraction of port height, h/d ; where h is the height of interface level above the bottom of the port and d is total height of port. Pressure drop will be expressed as feet of water head in this paper. In Figure 5 the solid lines represent the typical case given in Figure 4b. Up to point I_1 (the level of the entering interface) in this example, the pressure drop resulting from flow through the port for the heavy phase, ΔP_H , is constant and at a value less than ΔP_N (the ΔP if the interface were at the normal position). From point I_2

upwards (above the downstream interface) the pressure drop for the light phase, ΔP_L , is again constant, but at a value higher than ΔP_N . The change in pressure drop with respect to the location (h) within the port and between the two interface positions (I_1 and I_2) is a function of the difference in density between the two phases. Thus, in terms of the light phase head

$$\frac{d\Delta P}{dh} = \frac{\rho_H - \rho_L}{\rho_L} \quad (2)$$

(feet of light phase head/unit change in interface height)

The reciprocal of Equation (2), expressed as a fraction of port height ($\Delta h/d$) and as feet of water head ($\rho H_2O = 1$), is Equation (3) which represents the slope of the line joining the interface positions, that is, I_1 and I_2 , when the coordinates are constructed as in Figure 5. The slope will be positive when the entering interface is above the normal interface position and negative when below the normal position.

$$\frac{d\Delta h/d}{d\Delta P} = \frac{1}{(\rho_H - \rho_L)d} \quad (3)$$

For a given equipment and flow there is actually an infinite number of these variable ΔP lines, depending on the position of the entering interface which can vary throughout the unit. Typical ones are shown by the dotted lines ΔP_2 and ΔP_3 in Figure 5. This family of variable ΔP lines can be defined by two additional curves which are the locus of all points I_1 and I_2 (heights of the interface at the upstream and downstream sides of the port) vs. the ΔP required for these heights. The formulas for the locus of points I_1 and I_2 constitute operating lines used in the graphical calculation of flow capacity being presented here, and can be obtained by calculating the pressure drop required to give flow of each phase through various percentages of the total port area. In order to simplify the calculation of these operating lines the following assumptions are made:

a. Only flow through the areas of constant ΔP are considered, that is, those areas where one phase is on both sides of the port. Where the ΔP (and velocity) are changing, the flow is assumed to be zero. The error introduced by this assumption is generally negligible. This is discussed in a later section.

b. The port openings will be rectangular. For other shaped ports the equations would be somewhat different.

Making these assumptions gives relatively simple equations for the operating lines. As previously indicated, the concept of velocity heads is used for calculating the pressure drop, Equation (1). If a is the fraction of port height cov-

ered by the heavy phase at the normal interface position and x is the distance from the lower interface to the normal interface for the port considered (as a fraction of port height), then

$$\frac{\Delta P_H}{\Delta P_N} = \frac{a^2}{(a+x)^2} \quad (4)$$

(x values are negative when below normal)

For the light phase let b represent the fraction of port height covered by the light phase at the normal interface and y represent the distance from the higher interface to the normal interface expressed as a fraction of port height. Then

$$\frac{\Delta P_L}{\Delta P_N} = \frac{b^2}{(b-y)^2} \quad (5)$$

(y values are negative when below normal).

Having calculated ΔP_N , Equations (4) and (5) give a diagram as shown in Figure 6 (solid lines). These curves give the pressure drop required to get the desired flow through the port height indicated; in this calculation the pressure drop through the regions of variable ΔP is ignored. This diagram, together with the slope of the variable ΔP lines, is sufficient to calculate the total interface rise for the two-phase unmixed flow through any number of cocurrent ports. For example, starting with an interface level as given by point I_1 (Figure 6) and proceeding along a line of slope given by Equation (3) to I_2 , give the interface level on the downstream side of the first port. Continuing from I_2 to I_3 gives the level on the downstream side of the second port. Any number of cocurrent resistances can be handled in this way.

In the mixer-settler unit after two cocurrent ports in a stage have been passed, the two phases are separated and each flows to one of two adjacent stages. An appreciable change in interface normally accompanies this flow from stage to stage. Figure 7 shows the pressure-depth diagram for two adjacent stages. For example, going from the upstream interface (point I_1) in the first stage to the downstream interface (point I_2) in the next stage (upstream for heavy phase flow) effects a rise in the interface equal to ΔH . ΔH can be calculated from Equation (6).

$$\Delta H_{1-2} = \left(\frac{\Delta P_{HL}}{\rho_H - \rho_L} \right) \left(\frac{1}{d} \right) \quad (6)$$

where

d = port height

ΔH_{1-2} = interface height change between chambers 1 and 6

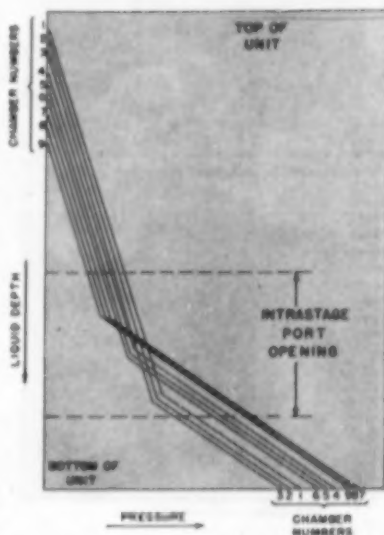


Fig. 3. Static pressure vs. depth for a three-stage mixer-settler with no agitation.

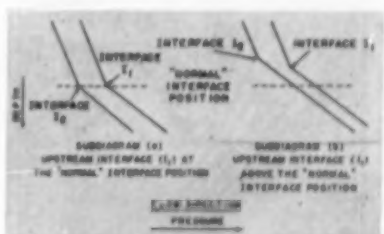


Fig. 4. Pressure vs. depth gradients within two adjacent chambers of one stage of a mixer-settler unit.

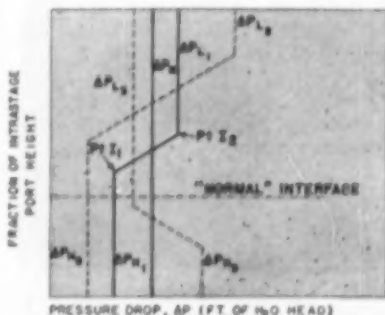


Fig. 5. Pressure drop through a cocurrent port vs. vertical position relative to port height.

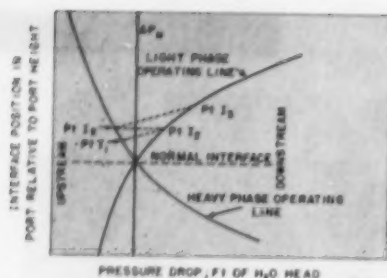


Fig. 6. Pressure drop for each phase vs. upstream and downstream interface position.

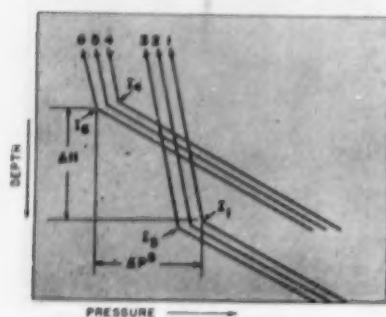


Fig. 7. Pressure relationships involved in calculating the change in interface height between stages.

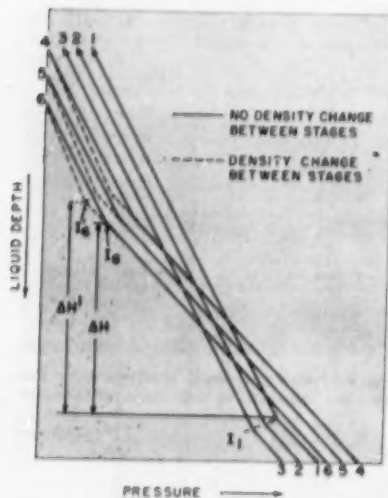


Fig. 8. Effect of change in density between stages.

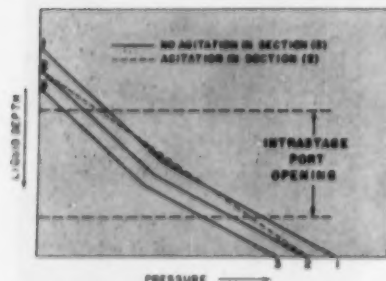


Fig. 9. Static pressure vs. liquid depth for one stage of a mixer-settler for no agitation and for agitation in the mixing section (2).

$$\Delta P_{SL} = \Delta P_{L1-2} + \Delta P_{L2-3} + \Delta P_{L4-5} + \Delta P_{L5-6} + \Delta P_{L3-4} + \Delta P_{H'6-1} \quad (\text{all in feet of water head})$$

Likewise from point I_3 to point I_4 (from section 3 to 4)

$$\Delta H_{3-4} = \left(\frac{\Delta P_{SH}}{\rho_H - \rho_L} \right) \left(\frac{1}{d} \right) \quad (7)$$

where:

$$\Delta P_{SH} = \Delta P_{H1-2} + \Delta P_{H2-3} + \Delta P_{L4-5} + \Delta P_{H5-6} + \Delta P_{L3-4} + \Delta P_{H'6-1} \quad (\text{all in feet of water head})$$

Either equation may be used. However, use of Equation (6) is preferable when below the normal interface, whereas Equation (7) is simpler to use above the normal interface. In either case, in calculating ΔP_{SL} , $\Delta P_{L'}$ (pressure drop for light phase) and $\Delta P_{H'}$ (pressure drop for heavy phase) represent one-phase flow through interstage ports and can be calculated by Equation (1) above. ΔP_{1-2} and ΔP_{2-3} are obtained from the operating lines (Figure 6) with the aid of Equation (3). The other two, ΔP_{4-5} and ΔP_{5-6} , refer to pressure drops in the next stage and must be obtained by trial and error (by making successive assumptions for ΔH). In practice this is quite simple and normally the first trial will be close.

These equations are sufficient to calculate the interface level in each stage of a multistage mixer-settler unit with no agitation. Calculation should be started in the stage where the heavy phase leaves. The first variable ΔP line is set tangent to the operating line or in the lowest position possible. In the operation of an actual unit this interface is also set near the bottom of this intrastage port by adjusting the heavy phase draw-off rate. A lower setting gives no advantage. Calculations are then continued backflow against the heavy-phase flow by the use of the methods given in the preceding paragraphs. A sample calculation is given as an illustration in the Application of Design Principle on page 297.

EFFECT OF DENSITY CHANGES

Density changes may occur at different points in the mixer-settler units owing, for example, to temperature changes or to the extraction of one or more components from one phase to the other. These density changes, which can have a large effect on flow capacity, can be accounted for in the graphical calculations by the mere use of the correct pressure gradients (density) for each stage during the computation. For example, the solid lines (Figure 8) represent the case where no change in density

of either phase occurs between stages. Now, if the light phase in the stage containing chambers 4, 5, and 6 is lighter than it is in the stage containing chambers 1, 2, and 3, the pressure gradients are as is indicated by the dotted lines. Thus, the increase in interface height between chambers 6 and 1 is expressed by $\Delta H'$ (Figure 8) and is greater than ΔH , the change in interface level for the no-change in density case.

EFFECT OF FLOW IN VARIABLE ΔP REGION

One of the assumptions made in developing the graphical method for calculating flow capacities was that no flow occurred through the region of variable ΔP . This will tend to make the calculated capacities lower than those that would actually exist. However, in practice, this error is usually not large as only a small fraction of the port area is covered by the variable ΔP region (note the small change in the interface level across any intrastage port in the sample calculation, Figure 10).

OPERATION WITH AGITATION

With full agitation in the mixing sections, the flow characteristics in the multistage units are somewhat different. From an inspection of the flow diagram in Figure 9, it can be seen that backflow of the mixed phase will take place between the mixing chamber and the preceding calming chamber (2 and 1, respectively). In this figure the solid lines represent the pressure gradients which exist in the various chambers with no agitation. When the agitator is operating in the mixing chamber, there is a single dispersed phase. Thus, the pressure gradient is represented by a single straight line (as shown by the dashed line). It is apparent that there is a zone within the port opening where the pressure in the mixing chamber (for a given horizontal plane) is higher than that in the calming chamber. Such a condition results in backflow which reduces the capacity of the unit seriously. Thus, in order to obtain in practice the flow capacity for multistage units which has been calculated for the no-agitation case (where the sole driving force for flow is gravity), the energy available in the agitators must be properly directed to compensate for this backflow. By the proper utilization of the agitator energy as discussed here, the flow capacity can readily be raised above that level calculated for the no-agitation case. Thus, it follows that the design for the no-agitation case is the conservative design permitting operation without flooding for the whole range of agitator speeds (that is, for agitators turned off to turned on full).

SAMPLE CALCULATION

A sample calculation based on a small three-stage unit is presented here to demonstrate the method. Pressure lines will correspond qualitatively to those shown in Figure 3. The problem is to calculate the final interface height (section 9) at a given flow rate for a given mixer-settler unit design. All assumptions used in the development for the no-agitation case are followed. The pressure drop through the interstage holes is taken as 2.5 velocity heads (K) and through the intrastage ports (which are baffled) as 4.0 velocity heads, Equation (1).

From Equations (4) and (5), the operating lines are then calculated and plotted in Figure 10 with h/d vs. ΔP_L (and ΔP_H). Stepwise calculations are then started beginning with the last water settling chamber 3 (stage 1, Figure 2). The interface level here can be adjusted in practice by regulating the water draw-off control. It should be set low enough to avoid affecting the interface level in other sections of the mixer-settler. Based on the assumptions made, the level would be given by the variable ΔP line tangent to the heavy-phase operating line.

The slope of the variable ΔP line is given by Equation (3). For this case:

$$\text{slope} = \frac{1}{(0.99 - 0.87)(.073)} \\ = 114 \text{ port heights/ft. of water head}$$

Starting with the tangent line and going back up the water stream, the ΔP change through the first two cocurrent ports is stepped off. The intersections with the operating lines give the interface height at these points. The numbers correspond with the section numbers in Figure 2.

The interface change between this stage and the next is calculated as follows:

$$\Delta P_{HL} = \Delta P_{L1-2} + \Delta P_{L2-3} \\ + \Delta P_{L4-5} + \Delta P_{L5-6} \\ + \Delta P_{L7-8} + \Delta P_{H7-8}$$

$$\Delta P_{L1-2} = .000123 \text{ ft. from diagram}$$

$$\Delta P_{L2-3} = .00013 \text{ ft. from diagram}$$

$$\Delta P_{L4-5} = .000153 \text{ ft.}$$

$$\Delta P_{H7-8} = .000019 \text{ ft.}$$

$$\text{assume } \Delta H_{L-6} = .084 \times \text{port height}$$

$$\Delta P_{L5-6} = .00016 \text{ ft. from diagram} \\ (\text{after assumption})$$

$$\Delta P_{L5-6} = .00016 \text{ ft. from diagram} \\ (\text{after assumption})$$

totaling:

$$\Delta P_{HL} = .00074 \text{ ft.}$$

Check

$$\Delta H = \left(\frac{\Delta P_{HL}}{\rho_H - \rho_L} \right) \left(\frac{1}{d} \right) \quad (6)$$

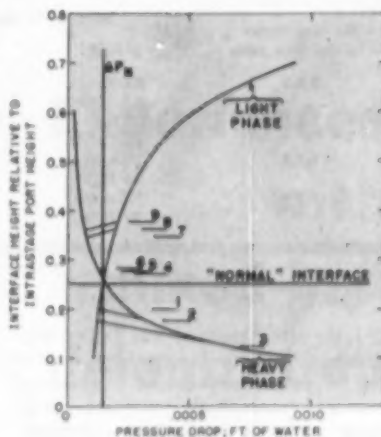


Fig. 10. Operating diagram for the sample problem.

$$\Delta H_{L-6} = \frac{.00074}{0.12} \left(\frac{1}{.073} \right) \\ = .0834 \times \text{port height}$$

The assumed and calculated values of ΔH are close enough so that another trial is not required.

The interstage interface rise between this middle stage and the next is then calculated from 6 to 7. As the interface in the final stage is above the normal interface, the steps in this stage are made upward in going from 7 to 9 and Equation (7) is used.

If line No. 9 did not intersect with the light phase operating line, the unit's capacity would have been exceeded and at the flow rates assumed, the unit would flood.

The total drop in the top liquid level throughout the unit is determined by summing all the ΔP_L 's (in feet of water) for the entire unit and dividing by the density of the light phase.

Known Values

| | |
|----------------------------|-----------------|
| Interstage port area | = .00304 sq.ft. |
| Intrastage port area | = .0053 sq.ft. |
| Intrastage port height (d) | = .073 ft. |
| Flow of light phase | = 40 lb./hr. |
| Flow of heavy phase | = 15 lb./hr. |
| Density of light phase | = 0.87 |
| Density of heavy phase | = 0.99 |
| Weight average density | = 0.90 |

Calculated Values

For interstage ports

| | |
|-----------------|-----------------------------------|
| v_{L1} | = .067 ft./sec. |
| v_{H1} | = .022 ft./sec. |
| ΔP_{L1} | = .000153 ft. of H ₂ O |
| ΔP_{H1} | = .000019 ft. of H ₂ O |

For intrastage ports with normal interface

| | |
|--------------|-----------------------------------|
| v_H | = .0513 ft./sec. |
| ΔP_H | = .000143 ft. of H ₂ O |
| a | = 0.25 port height |
| b | = 0.75 port height |

GLASS MIXER-SETTLER

A glass laboratory mixer-settler unit was constructed in order first to check the validity of the proposed method for calculating the flow capacity for the no-agitation case, and second to uncover modifications in the units which would lead to higher capacities (especially in the agitation case). This model was constructed in an unfolded fashion (Figure 2), thus permitting a close study of the flow pattern within the unit.

Water and benzene were metered to the glass unit at a predetermined flow ratio. The flow of each stream was gradually increased with no agitation until the interface in the last settling

section rose above the intrastage port (dividing the mixing and settling chamber). This velocity was termed the flooding velocity. Actually, operation could be maintained steady when the interface was above the port area in the last settling section, but the control became extremely sensitive. The flooding velocities with agitation were determined in the same manner and with the same flow ratios as were used in the nonagitated case.

The observed flooding velocities for the no-agitation cases compared well with the calculated flooding velocities when the flow ratios of the two phases were close to unity (Table 1). However, in this small unit another effect

became important when the two liquid flows were greatly different.

When the ratio of benzene to water flow was high (9.8:1), the actual capacity of the unit was lower than theoretical. This was due to a surface tension effect. The benzene wetted the walls of the port openings better than did the water. Therefore, the meniscus of the water was concave down; this reduced the free area for the water to flow. The area available for water flow was already small due to the large flow of benzene. This decrease in area resulted in a higher pressure drop than calculated for the water flowing (assuming no surface tension effect). When the ratio of benzene : water was low (1 :

Table 1.

| Benzene:Water volume flow ratio | Flooding Rate (lb./hr.) | | |
|------------------------------------|-------------------------|----------------------|----------------------|
| | no agitation | with agitation | |
| | theor. | actual | actual |
| 9.8:1 | 53 Bz | 40 Bz | 10 Bz |
| | 6.2 H ₂ O | 4.6 H ₂ O | 1.2 H ₂ O |
| 1.9:1 | 35.5 Bz | 38 Bz | 12.4 Bz |
| | 21.5 H ₂ O | 23 H ₂ O | 7.5 H ₂ O |
| 1:1.5 | 20.6 Bz | 21 Bz | 6.1 Bz |
| | 34 H ₂ O | 35 H ₂ O | 10 H ₂ O |
| 1:5.9 | 7.5 Bz | 9.45 Bz | 1.6 Bz |
| | 50 H ₂ O | 63 H ₂ O | 10 H ₂ O |

5.9), the actual capacity was higher than calculated. Here, the surface tension was helpful as the port area for benzene flow was substantially increased giving lower pressure drops than calculated. This effect, though substantial in the laboratory unit where the port openings were only $\frac{3}{8} \times \frac{3}{8}$ in., proved to be of minor consequence in the large plant units.

With the baffle arrangement as shown in Figure 2, that is, closed at sides and open at top and bottom, the capacity of the glass mixer-settler was markedly decreased when agitation was started (see Table 1). The resistance to the flow into the mixing sections was higher than anticipated due to backflow of the mixed phase into the calming sections. A study of the operation of the small laboratory unit showed that the following modifications to mixer-settlers would increase their flow capacities to values above those calculated for no agitation.

Staggering of Intrastage Ports

The capacity of mixer-settlers can be increased by staggering the ports in height, rising in the direction of the lighter phase flow.

Pumping

In general, other methods of increasing the capacity of mixer-settler-type units depend on additional outside energy to pump liquids from stage to stage. This may be accomplished in a number of ways. Normally, it will be sufficient to pump only the heavier phase, and to allow the lighter phase to flow by gravity. In some systems, however, both phases are generally pumped from the mixing section in a mixed state.

Pumping has been obtained in mixer-settlers by the use of ingeniously designed agitators (4) which promote the flow of the mixed phase. However, it was found in the glass mixer-settler that its capacity could be markedly increased by merely utilizing the kinetic energy

developed by the conventional paddle-type agitators. By the elimination of the downstream baffle in the mixing sections the capacity of mixer-settlers was greatly increased owing to the pumping effect of the agitator. Removal of the upstream baffles in the mixing sections made the unit inoperable owing to high backflow. Obviously, if the baffle on the downstream side of the agitator is removed, the mixed phase will be pumped into the settling chamber. This would require that the settling chambers be unduly large.

It was found that the desired pumping action could be obtained with the agitator without affecting the settling time by proper modification of the baffles in the mixing chamber. The baffles, as indicated in Figure 2, were originally closed at the sides and opened at the top and bottom. By merely opening the side of the downstream baffles which faced the direction of the agitator rotation, the pumping action was found to be at the desired level. By this modification, the swirl set up by the agitator caused the flow of the mixed phase into the settling section at virtually 90 degrees to the direction of flow of the main body. Therefore, the disturbance set up in the settling section was reduced to a minimum.

Literature Cited

- Brothman, A., and H. Kaplan, *Chem. Met. Eng.*, **46**, 633-636 (1939).
- *Chem. Eng.*, **286** (January, 1954).
- *Chem. Eng.*, 132-134 (March, 1954).
- Coplan, B. V., J. K. Davidson, and E. L. Zembraskie, *Chem. Eng. Progr.*, 403-408 August, 1954).
- Davis, M. W., Jr., T. E. Hicks and T. Vermeulen, *ibid.*, 168-197 (April, 1954).
- Hixson, A. W., and S. J. Baum, *Ind. Eng. Chem.*, **34**, 194-208, (1942).
- Hixson, A. W., and V. D. Lueddecke, *Ind. Eng. Chem.*, **29**, 927-933 (1937).
- *Ind. Eng. Chem.*, **30**, 489-500 (1938).
- Kramers, H. A., G. M. Boers, and W. H. Knoll, *Chem. Eng. Sci.*, **2**, 35-42 (1953).
- Olney, R. B., and G. J. Carlson, *Chem. Eng. Progr.*, **43**, 473-480 (1947).
- Perry, J. H., "Chemical Engineers Handbook," New York, McGraw-Hill Book Company, 1195-1230, 3 ed. (1950).
- Quillen, C. S., *Chem. Eng.*, 179-196 (June, 1954).
- Rushon, J. H., *Chem. Eng. Progr.*, **48**, 95-102 (1952).
- Rushon, J. H., E. W. Costlich, and H. J. Everett, *Chem. Eng. Progr.*, **46**, 395-404, 467-476 (1950).
- Wingard, R. E., M. N. Vinyard, and C. H. Craine, Jr., *Alabama Polytech. Inst., Eng. Expt. Sta., Eng. Bull.*, No. 17, 3-21 (1952).

Acknowledgment

Thanks are hereby expressed to C. H. Hamblet, of the Polychemicals Department of Du Pont, who assisted in guiding both the research work on this problem and the preparation of this paper.

Notation

Stage consists of an impounding chamber, a mixing chamber, and a settling chamber.

A, B = intrastage flow ports

C, D = interstage flow ports

g = gravitational constant 32 ft./sec./sec.

v = fluid velocity ft./sec.

K = factor depending on geometry of flow port

h = height of interface above bottom of port, ft.

d = vertical dimension of port, ft.

Δh = change in interface height across an intrastage port

l_1, l_2 = interface references in sections 1, 2

ΔP = pressure drop, $P_1 - P_2$, ft. fluid

ΔP_F = pressure drop existing when interface at normal position

ΔP_L & ΔP_H = pressure drop for light phase and heavy phase, respectively, across intrastage ports

ΔP_L & ΔP_H = pressure drop for light phase and heavy phase, respectively, across interstage ports

a = fraction of port height covered by heavy phase at normal interface position

x = distance from the lower interface to normal interface position for port considered (as a fraction of port height)

b = fraction of port height covered by light phase at normal interface position

y = distance from higher interface to normal interface position for port considered (as a fraction of port height)

ΔH = change in interface level as one phase flows to next adjacent stage, ft.

The author reviews various sources of operating difficulty encountered experimentally in purifying feed water and describes a modified operating procedure by which these difficulties—namely, the lack of pretreatment of the feed water and poor regeneration—have been overcome.

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Experiences with mixed-bed deionization of water

Purification of water by mixed-bed ion exchange, introduced in 1949, offers a simple, low-cost method for obtaining large volumes of water of a purity not hitherto available. This method was of immediate interest in the manufacture of chemicals because such water could be produced economically on a large scale. For example, water having an average specific resistance of greater than 5×10^6 ohm-cm. could be produced at one third to one fifth the cost of distilled water, which has a specific resistance of only 1 to 2×10^6 ohm-cm. Various aspects of this process have been described previously (4). When it is desired to produce pure water by this process, the reproducibility of operation is more sensitive to a number of external and internal factors than appears to be commonly understood.

Previous Methods

Mixed-bed deionization is a batch process in which a mixture of acidic and basic resins is used to adsorb impurities from water. The operation is a cyclic one in which the resins are first activated or regenerated by chemical treatment and then used to purify water until the resins are spent, after which they are again regenerated. Many different methods have been proposed to regenerate the mixture of resins, and all methods have two points in common. The mixture of the two resins is sepa-

rated into two layers of the individual resins by backwashing with water at an appropriate rate, and one or more of the chemical waste solutions produced in regeneration are removed by a single waste collector located approximately at the interface between the two layers of the resins.

A typical regeneration procedure is shown in Figure A. The major steps shown are:

(1) backwashing to separate the bed into two layers, (2) passage of caustic soda solution down through the entire bed, (3) passage of hydrochloric acid up through the bottom layer of resin and out the interface waste collector, (4) rinsing, and (5) remixing of the resins by air agitation.

In some other modifications of this method, the direction of flow of the regenerant through the layer of acid resin may be reversed and the regenerants may be introduced simultaneously.

Difficulties have been encountered on occasion with most of the methods of operation which have been proposed. Some of these difficulties are associated with the lack of pretreatment of the feed water and others with poor regeneration.

Sources of Operating Difficulty

LACK OF PRETREATMENT OF FEED WATER

Suspended finely divided solids. On two separate occasions, the quality of the deionized water and the capacity of the

bed to produce such water were reduced by the presence of suspended finely divided solids in the feed water. On one occasion, the feed water contained almost colloidal iron oxide, some of which passed through the bed and was present in the treated water, and the rest coated the particles of the basic resin in the bed. The adsorbed oxides could be removed by washing with dilute hydrochloric acid before regenerating with caustic soda. On a second occasion, the basic resin was fouled by water containing both Calgon and iron oxides. The same hydrochloric acid reactivation procedure was successful.

Suspended bubbles of air. The capacity of a bed to produce pure water was greatly reduced when the feed water was milky with suspended air bubbles. The reduction in capacity in one instance was about 80%. The milky water was produced by improper operation of a pressure-oxidation clarification unit. Presumably the reduction in resin bed capacity was caused by channeling through the resin bed.

Surface-fouling impurities. On one occasion, the ability of the strongly basic trimethylamine-type resin to produce pure water was completely and permanently impaired after three cycles by the adsorption of an impurity on the surface of the resin. The impurity could not be removed by treatment of the resin with caustic soda or Calgon although it was partially eluted by strong brine. The brine effluent was bright yellow in color, which disappeared on acidification and

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reappeared on alkalization. It is suspected that the impurity is organic and may be woody or earthy in nature. The basic resin after regeneration with caustic soda retained practically all of its salt-splitting capacity although it could no longer produce water having a specific resistance of 10^7 ohm-cm. Hence, it was concluded that the impurity was a fairly large molecule which "poisoned" the surface of the resin.

POOR OPERATION OR REGENERATION

Precipitation of calcium and/or magnesium. On two separate occasions, the resin bed could not be rinsed to obtain water above a specific resistance of 1 to 2×10^6 ohm-cm. In one case, a white precipitate was observed in the waste effluent before rinsing, and qualitative analysis showed hardness was present in the rinse water. It is thought that in both cases the poor rinse was caused by

precipitation of calcium sulfate and/or calcium and magnesium hydroxides in the bed and subsequent removal of these precipitates in the rinse water.

Precipitation of silica. In one instance, a precipitate of what was later found to be silica was formed in the bed on regeneration. Because it was believed initially that the precipitate was iron oxide, the resin was acid washed and then treated with caustic soda. The precipitate was not dissolved and the resin had to be discarded. (It is now considered best, because of the possibility of silica precipitation, to clean up a mixed-resin bed by treatment first with alkali and then with acid.)

Evolution of carbon dioxide gas. Initial deionization experiments were made in glass tubes at atmospheric pressure. It was noticed that gas bubbles formed at the top of the bed soon after the flow of feed water was started and that these bubbles continued to form lower and

lower in the bed. When the bubbles formed at the bottom of the bed, which happened after about one third of the expected run time, the quality fell off and the run had to be terminated prematurely. This behavior disappeared when the pressure was raised above about 10 lb./sq.in. Subsequent atmospheric pressure experiments with a de-carbonated feed did not result in bubble formation, and hence it is concluded the gas was carbon dioxide.

Elimination of Operating Difficulties

FEED PRETREATMENT

From the preceding observations, it is apparent that the resin bed is a poor mechanical filter for suspended finely divided solids even though it is a superlative chemical filter for dissolved electrolytes. Suspended solids have been eliminated by the use of a cellulose-mat-type pressure filter. Satisfactory results have been obtained with well water, turbine condensate, and water which has been clarified by conventional chemical coagulation or by pressure oxidation of soluble iron.

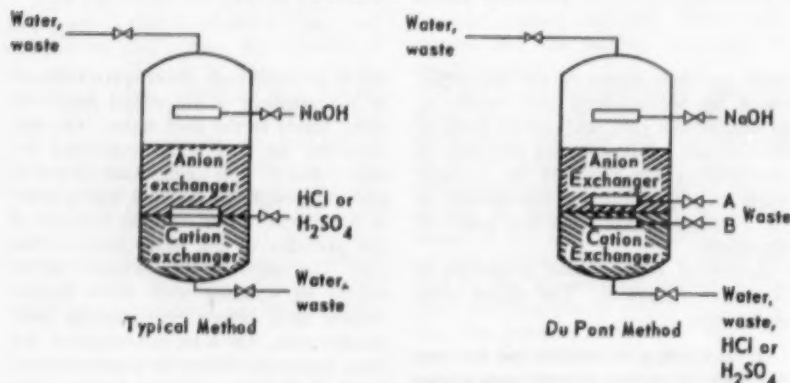
The problem of dissolved surface-fouling materials has not been solved although carbon adsorption appears beneficial. In all cases where mixed-bed deionization is contemplated, a field test is made to assure absence of such materials. Up to the present, the problem has not recurred after six field trials. It should be noted that this difficulty appears to be inherent in the use of the strong-base quaternary amine-type resins in general, although it may be more noticeable in mixed-bed operation where purity is so high.

REGENERATION

The elimination of potential difficulties in regeneration can be achieved by proper design and choice of chemicals. The procedure developed in the course of this study has given satisfactory results and appears to be sufficiently novel to warrant description. It is not implied, however, that high-purity water cannot be produced by other procedures or that production of high-purity water automatically means that precipitation is not occurring. For example, control experiments on regeneration with hydrochloric and with sulfuric acid, with the procedure proposed in this paper, have given water having a specific resistance greater than 10^7 ohm-cm, even though the 50% lower capacity found with sulfuric acid can hardly be attributed to any factor other than precipitation of calcium sulfate in the bed.

In another case, high-purity water was produced in one of the conventional methods even though the waste effluent

Fig. A. Mixed-bed ion exchange process.



REGENERATION PROCEDURE

- | | |
|---|--|
| 1. Wash the bed of mixed exchangers upflow with soft water to classify it into two layers as shown above. | 1. Same. |
| 2. Pass caustic downflow through entire bed. | 2. Pass caustic downflow and remove at waste collector A. At same time, pass soft water up through bottom layer of exchanger and remove at A. |
| 3. Rinse out excess caustic. | 3. Same. |
| 4. Pass hydrochloric acid down through bottom layer of exchanger. | 4. Pass hydrochloric acid up through bottom layer of exchanger and remove at waste collector B. At the same time, pass soft water down through the upper layer of exchanger and remove at B. |
| 5. Rinse out excess acid. | 5a. Same. 5b. Wash the entire bed upflow with soft water to insure adequate rinse. |
| 6. Lower the liquid level and mix the exchangers by agitation with air. | 6. Same. |
| 7. Settle the bed, fill the tank with water from the top. | 7. Same. |
| 8. Start the run. Feed water enters at the top, flows down through the bed, and leaves at the bottom. | 8. Same. |

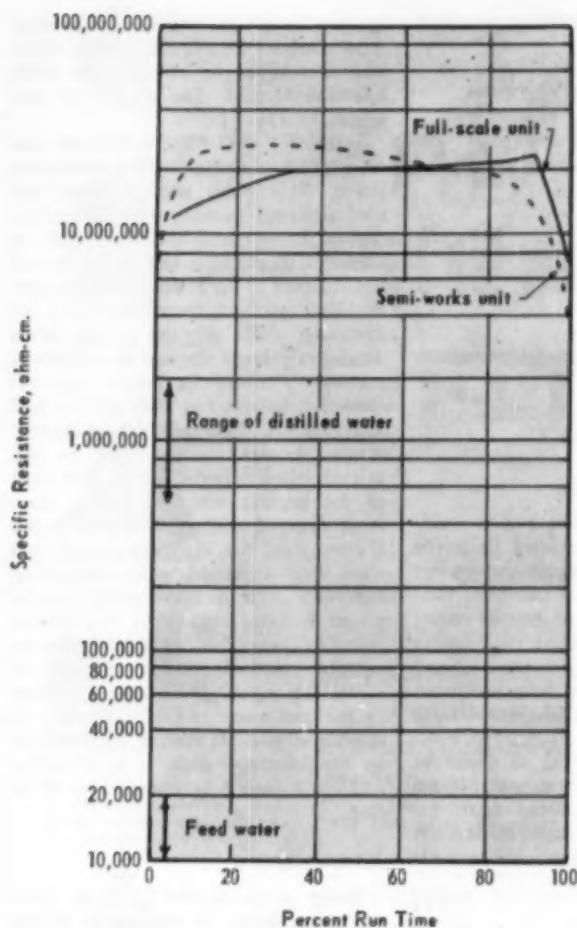


Fig. 1. Electrical resistance of deionized water.

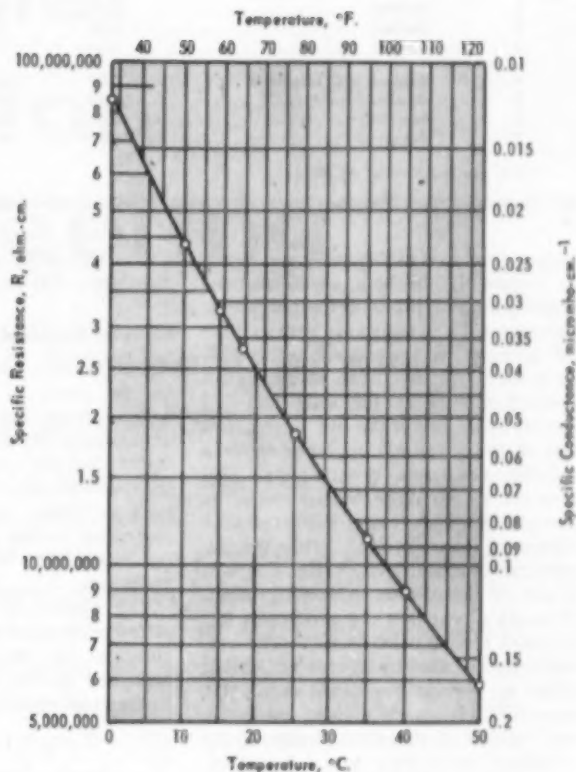


Fig. 2. Theoretical electrical resistance and conductance of pure water at various temperatures.

on regeneration was known to contain precipitated silica. All that is claimed of the proposed procedure is that it has a much higher margin of safety in regeneration compared to the present methods. This is supported by the fact that two full-scale mixed-bed deionizers under the proposed procedure have been in continuous operation since startup, February, 1951, without failure to regenerate and produce pure water. Such performance is considered necessary in some branches of chemical manufacture where production would be halted if pure water were not available, as contrasted to power operation where temporary reduction in purity of the boiler feed water would be compensated for by increased blowdown.

The method developed is shown in Figure A, where one of the present typical methods is represented by way of comparison. Although the steps in regeneration are described in detail in this illustration, the important differences between the two methods are as follows:

(1) two waste collectors are used in place of one at the interface between the two layers of resin, one collector being just inside the layer of basic resin and the other just inside the layer of acid resin, (2) each regenerant solution is removed at a waste collector simultaneous with a counterflow of water which is being passed through the bed in a direction opposite the direction of regenerant flow, and (3) a final rinse is given to the resins and the underdrain system by backwashing (i.e., upflow rinsing) the bed after regeneration.

The purpose of the two waste collectors and the counterflow of water is to insure that the regenerants contact only the appropriate layer of resin. For example, the basic resin is the upper layer and the acid resin is the lower layer. With the simultaneous introduction of caustic soda solution at the top of the bed and water at the bottom, and by the removal of both solutions by a collector located inside the layer of basic resin, no caustic soda or waste products (i.e.,

silicates and carbonates) are permitted to enter the lower layer of acid resin. In this way, no alkali enters the acid resin to precipitate calcium and magnesium adsorbed on the acid resin, and no silicates or carbonates contact acid resin which might cause the formation of carbon dioxide gas or a precipitate of silica. No sign of gas or precipitate formation has been observed by the employment of this method. The small amount of unregenerated resin between the two waste collectors has no effect on the purity of the deionized water. The backwash rinse after regeneration may be superfluous, but it is good insurance that the bed and the underdrain system have been well rinsed. Even tiny pockets of regenerant solutions can reduce greatly the resistance of the deionized water produced.

Results of Procedure

Typical semiworks and plant results obtained with the regeneration pro-

Table 1.—Analysis for Silica Content

| Sample no. | Water treatment | Inorganic solids p.p.m. | Organic solids p.p.m. | Total solids p.p.m. |
|------------|-------------------------------|-------------------------|-----------------------|---------------------|
| 1 | distilled | 0.04 | 0.32 | 0.36 |
| 2 | distilled | 0.03 | 0.22 | 0.25 |
| 3 | distilled | — | — | 0.33 |
| 4 | distilled and deionized | 0.00 | 0.10 | 0.10 |
| 5 | deionized | 0.03 | 0.07 | 0.10 |
| 6 | deionized | 0.03 | 0.12 | 0.15 |
| 7 | deionized | 0.57* | 0.02 | 0.59 |

* This was found to be all silica.

cedure developed in this study are shown in Figure 1. In both cases—namely, semiworks and plant—deionized water, having a specific resistance greater than 10^7 ohm-cm., was produced during 90% or more of the run. The resistance increased rapidly at the start and fell rapidly at the end of the run. Irregularities in the shape of the curve above a specific resistance greater than 10^7 ohm-cm. appear large, but are caused by almost negligible changes in the recorded values of conductivity. With the reciprocals of conductivity values and with a plot of the results on semilog paper, it would appear that the purity was less constant than it actually was. The conductivity cell used had a constant of 0.01 (that is, specific resistance equals the measured resistance divided by 0.01), and values of the conductivity of the deionized water were recorded continually at 0.5-min. intervals throughout the run.

The plant-scale equipment consists of two mixed-bed deionizers, each 3 ft. diam. by 9 ft. high. The resin bed in each tank consists of 15 cu.ft. of a trimethylamine-type strong-base resin and 10 cu. ft. of a high capacity sulfonated-polystyrene-type strong-acid resin. The basic resin is regenerated with 6 lb. caustic soda/cu.ft. resin, and the acid resin with 6 lb. hydrochloric acid/cu.ft. resin, each applied at about 5% by weight. By the use of a feed water containing 50 to 100 p.p.m. dissolved solids, each deionizer will produce 30,000 to 50,000 gal. water between regeneration. The rate of water flow is about 25 to 35 gal./min., or about 5 gal./ (min.) (sq.ft. of bed cross-sectional area). The units have been in constant production since February, 1951, and have always produced high-purity water after regeneration. The installed investment and the operating cost of these deionizers are one third to one fifth of those of the most economical evaporative method known—namely, compression distillation. It is likely that this same cost differential between deionization and distillation will be obtained when

waters containing up to about 500 p.p.m. dissolved solids are used.

Purity of Deionized Water

Two methods have been used to evaluate the purity of mixed-bed deionized water. In the first method, the content of dissolved electrolytes has been estimated from the measured specific resistance; in the second method, nonvolatiles such as silica, organic materials, and suspended matter have been estimated by a modified A.S.T.M. evaporative procedure.

The electrolyte content of deionized water, expressed as dissolved sodium chloride, can be calculated from the measured specific resistance by the following two equations:

$$\frac{1}{R} = \frac{1}{r_{H_2O}} + \frac{1}{r_{NaCl}} \quad (1)$$

and

$$\log (r)(C)_{NaCl} = 5.888 - 0.00864 t \quad (2)$$

Equation (1) considers the resistance of water to result from the ionization of water and of salt, both resistances acting in parallel. The resistance of pure water is taken from (2) and is shown in Figure 2. Equation (2) is based on experimental data on the equivalent conductivity of sodium chloride at infinite dilution at 15 to 45° C. (3). In practice, R and r_{H_2O} are inserted in Equation (1) to calculate r_{NaCl} and then C_{NaCl} is calculated from Equation (2). For example, the specific resistance of mixed-bed deionized water is often greater than 10^7 ohm-cm. at room temperature. The equivalent amount of dissolved sodium chloride present is calculated from Equations (1) and (2) to be about 0.05 p.p.m.

The analysis of deionized water for its content of nonvolatile materials was based upon the A.S.T.M. procedure (1). In addition to a determination of total solids at a drying temperature of 105° C., it was found possible to estimate the organic content of the solids by

ignition in air at 500° C. for 15 min. After analysis for organic matter, silica was determined by volatilization with hydrofluoric acid. The results are presented in Table 1.

Samples 1 to 3 (Table 1) were run on a source of single-distilled laboratory water. This water was deionized and then analyzed (sample 4). The reduction in the inorganic solids from 0.03 to 0.04 to 0.00 p.p.m. seems to be beyond the accuracy of the method if one judges the identity of all the values found for inorganic solids content, except when a relatively large amount of silica was present. The organic solids were reduced by deionization from 0.22 to 0.32 to 0.10 p.p.m. This reduction in organic content by deionization is not so surprising when it is considered that most of the organic matter probably came from decayed matter. Samples 5 and 6 came from two different sources and show that deionized water comparing favorably with distilled water can be prepared from more than one source. Sample 7 shows that deionized water can contain relatively large amounts of silica, 0.6 p.p.m. From the character of the feed water in this instance, it is considered possible that the silica present in the deionized water was suspended and could have been removed by filtration.

Acknowledgment

Many people in the Du Pont Company contributed to the success of this project, especially W. J. Amend, T. B. Evans, W. L. Johns, C. S. Moore, W. J. Sloan, W. H. Taylor, Jr., and E. F. von Wettberg, Jr.

Notation

R = measured specific resistance, ohm-cm.
 r_{H_2O} = specific resistance of pure water, ohm-cm., taken at the same temperature as R .
 r_{NaCl} = specific resistance of water containing sodium chloride.
 C_{NaCl} = concentration of sodium chloride solution, p.p.m.
 t = temperature, ° C.

Literature Cited

- Am. Soc. Testing Materials, Standards, "Tentative Methods of Test for Suspended and Dissolved Solids in Industrial Water (Method A)," Part 5, 1544-9 (1949).
- Dorsey, N. E., Reinhold Publishing Corporation, New York, page 374 (1940).
- Gunning, H. E. and A. R. Gordon, *J. Phys. Chem.* 10, 126-131 (1942).
- Thompson, J., F. X. McGarvey, J. F. Wentz, S. F. Ailing, M. E. Gilwood, and D. R. Babb, *Chem. Eng. Progr.* 49, 341-348, 437-443 (1953).

Presented at A.I.Ch.E. meeting, Houston, Texas.



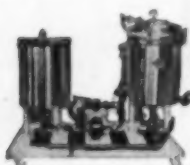
Laboratory filter.



Varnish and lacquer filter.



Plating solution filter (portable).



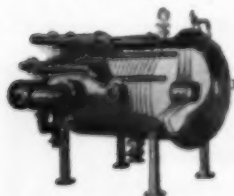
All stainless steel filter with stainless steel piping, valves, and slurry tank.



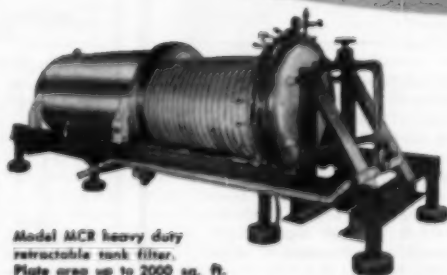
Standard horizontal plate filter.



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ford Chem. Wks. Author several papers phosphates & fertilizers. A.I.Ch.E. service: Tech. progr. chmn. Baltimore mtg. Sept. '57; mbr. Educ. Proj., Publications, Program & Awards Comm. Maryland Sect. chmn. ('51-'53). Chmn. Subcomm.—Student Contest Problem ('36).



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articles & patents on petroleum processing. A.I.Ch.E. service: Mbr. Inst. Sections (chmn. '55-) Student Contest (chmn. '54), Program (chmn. Process Div. '51-'53), Public Rel., Publications, Comms. Baton Rouge (chmn. '47) & Phila.-Wilm. (secy. '52-'53) Sections.



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deputy dir. ('53-'56), Engrg. Res. Lab. A.I.Ch.E. service: 50th Anniv. ('55-), Research ('50-), Program ('53-) (chmn. Div. 4, '54-'56) comms. Chmn. tech. program 50th Anniv. mtg. Various offices Phila.-Wilm. local sect.



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& equip. articles fluidized solids. Lecturer, Brooklyn Poly ('42-'46), Columbia U. ('42-'53). A.I.Ch.E. service: Chmn. symposia: proc. des. ('54); vacuum engrg. ('52); viscous mfrs. ('50). N. Y. Sect. mbr. Program Comm.



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'48) Cities Service Res. & Devel. Co.; Staff exec. ('51-'53) Nat'l. Gasol. & Petrochems., Cities Service Petroleum, Inc. A.I.Ch.E. service: Gen'l. chmn. NY meeting ('54); mbr. Research (chmn. '55), Program, Inst. Sections, Comms. Past chmn. NY and Oklahoma Sections.



RALPH A. MORGEN—Research executive & Educator. Res. dir. ('54-) & res. asst. to pres. ('56-) Purdue Research Foundation. Was program dir. for engrg. ('52-'54) National Science Foundation. Asst. ('24-'26) U. Calif.; devel. ('26-'28) Western Elec.; res.

mgr. ('28-'33) Cleaners Equip.; Consult. ('33-'38); prof. ('38-'52) & dir. ('47-'52) Exper. Sta., U. Florida. Author, patents, cleaning ind. A.I.Ch.E.: Educ. Accred. Comm. (chmn. '54); A.S.E.E. chem. engrg. div. (chmn. '43-'44); E.C.R.A. (dir. '50); E.C.P.D. Educ. Comm.



C. W. NOFSINGER—Consultant. Pres. ('50-) The C. W. Nofsinger Co. Devel. ('22-'26) Sinclair Ref.; Process & proj. engrg. admin., techn. sales, ('26-'45) M. W. Kellogg; chief technol. ('45-'50) Ref. Div., Petrol. Admin. for War; Consult. ('45-'50)

Sinclair Devel. & Stratford Engrg.; dir. & vice-chmn. Tech. Comm., mbr. Tech. Adv. Comm. ('52-) Fractionation Res. A.I.Ch.E.: One of founders, K. C. Sect. (chmn. '50); chmn. Arrangements Comm. K. C. Mtg. ('51). Lecturer, writer, pat. technol., catalytic & fluidized syst.



RICHARD H. WILHELM—Educator & Consultant. Prof. of chem. engrg. ('46-), chmn. of Dept. ('54-) Princeton U. Staff member at Princeton since 1934. Indus. consultant to pharmaceutical, chemical and petroleum firms. Numerous publications on engrg.

aspects of chem. reactor technology. Dir. ('46) Princeton bicentenn. conf. on Engrg. & Human Affairs. A.I.Ch.E.: Program, Awards (chmn. '54-'55), Research, History Comms.; Adv. Bd., A.I.Ch.E. Journal; N.J. Sect. (mbr. Exec. Comm.). Walker ('51) & Professional Prog. ('42) Awards.

DIRECTOR-CANDIDATES NOMINATED BY PETITION



EDWARD JORDAN FOX—Industrial executive. Vice pres. ('56-), Union Carbide Nuclear Co. With Carbide & Carbon Chemical Co. since 1930 as: tech. superv., dept. hd., & chem. area superv. ('30-'41) So. Charleston plant; asst. supt. produc. ('41-'43) Texas

City plant; supt. butadiene plant ('43-'46) Louisville; asst. supt. maint., engrg., utilities & auxiliaries ('46-'53), plant supt. ('53-'55), Texas City plant; asst. works mgr. ('55-'56) New York office. A.I.Ch.E.: South Texas Section, Exec. Comm. (mbr. '54).



EMERSON J. LYONS—Industrial executive. General mgr. ('46-) Turbo-Mixer Div., Gen. Amer. Trans. Corp.; Chem. engr. ('32-'36) Skenandoe Rayon; Since 1936 with Turbo Mixer as chem. engr. ('36-'45), genl. mgr. ('46-). Numerous publications on mixers &

mixing technol. A.I.Ch.E. service: Mbr. Admissions ('47-'51, '53-'56), Equip. Testing (Agitators Sub.Comm. since inception), Comms. Past Inst. repres. to E.I.C.; N. Y. Section: chmn. ('46), secy. ('43-'44). Lecture Course Comm. chmn. ('55), Student Guidance Comm. mbr. ('55).



EDGAR L. PIRET—Educator, consultant. Prof. ('45-) U. Minn. Intl. Fellow ('35-'36) U. Lyon. Consult. 3M Co. since 1937, chief, chem. engr. ('43-'45). Fulbright res. prof. ('50-'51) U. Nancy & Paris. Friedel Medalist U. Paris. European lectures ('50-'51, '54).

Medal U. Liege ('51). Bronze Medal Swedish Assn. Engrs. ('54). Consult. ('51-) N.R.Lab. Publ., patents: contin. reactor theory, crushing theory, fermentation, high vacuum, education. A.I.Ch.E.: Publication, Program, Intl. Ref. (E.I.C.). Comms.; Chmn. T. C. Sect.; Walker Award ('55).

POLYPROPYLENE AND OTHER "ISOTACTIC" POLYMERS—THEIR POTENTIAL AND PROBLEMS

The highly publicized development of isotactic polymers, led by polypropylene, polybutadiene, polystyrene and even polyisoprene rubber, is the subject of much speculation as to the extent and degree of impact on the engineering and marketing of polyethylene and polystyrene.

Montecatini, Italian chemical giant, in exclusive possession of a new process developed by Giulio Natta, is planning to build a commercial polyolefin plant in Italy, will license Natta's process in the U. S. But Ziegler in Germany, and Standard of Indiana, Phillips Petroleum, and other U. S. firms, are also at work on the isotactics.

Impressive is the commercial potential involved, the possible new and improved products, based on the physical properties claimed for the new polymers as well as the fact that propylene is a cheaper raw material than ethylene.

But there are quite a few chemical and engineering problems still ahead before commercial exploitation of the isotactics can get on-stream.

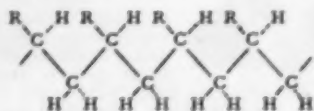
Even isotactic polypropylene has a melting point of only about 300° F. For many textile applications, this compares unfavorably with the figure of 428° F. for nylon. These olefin polymers are usually hydrophobic, difficulties may be expected in developing dyeing techniques. There also seems to be some question of their stability under irradiation, particularly with ultraviolet light.

Up to now, yields in the production of this type of polymer have been low. Natta claims that this difficulty has been overcome, states that solvent extraction is not necessary. He declines to say, however, whether Montecatini's commercial polypropylene process involves recycle features.

Physical Properties

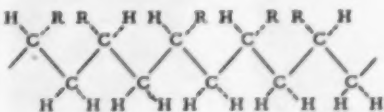
Starting with high molecular weight polypropylene (1), Natta succeeded, by solvent extraction, in isolating certain fractions which, under X-ray examination, appeared to be almost perfectly crystalline. Using the same type of catalyst, he then proceeded to make poly- α -butylenes and polystyrenes having the same general characteristics.

The isotactics show greater density, higher melting points, and better resistance to solvents than obtained in the amorphous types. These properties, according to Natta, are due to a regular, or "isotactic" steric arrangement of the monomeric units rather than a random distribution.



(Above) Schematic representation of isotactic structure—all R groups either above or below main plane of polymer chain (here shown as plane of paper).

(Below) Non-isotactic structure—random or statistical distribution of R groups.



Natta attributes (2) to the new polymers a structure in which, at least for long portions of the original chain, all the asymmetric carbon atoms have the same configuration. Since a planar structure is impossible, due to steric impediments between the R groups, spiralization of the principal chain must take place to reach the crystalline state. According to Natta's theories, therefore, polyethylene cannot have an isotactic structure because no R groups are present in the chain.

The actual catalysts used by Natta are thought to be of the metal-alkyl and metal halide types. It is said that their physical characteristics are more important than their chemical composition.

C. C. Price of the Department of Chemistry, University of Pennsylvania, described to CEP recent work in the United States which appears to corroborate Natta's results to some extent. 1-Propylene oxide has been polymerized as a solid crystalline polymer by the employment of a powdered potassium hydroxide catalyst (3). A liquid polymer of about the same weight has been produced from racemic oxide under the same conditions (4). By the use of a recently disclosed (5) complex ferric chloride catalyst, 1-propylene oxide has been polymerized to obtain a mixture of an amorphous, intermediate-molecular weight optically inactive polymer and a crystalline high-molecular weight polymer with X-ray diffraction lines and density consistent with a steric model

(Continued on page 54)



Quantity production of a product designated as 1707 Catalyst is now underway at Westvaco's Newark, Calif., plant (above). The new product, to be used in the manufacture of butadiene and styrene, is a metal oxide type of dehydrogenation catalyst containing a high proportion of magnesia.

The company, a division of Food Machinery and Chemical Corp., is also increasing production of barium oxide by some thirty per cent at its Modesto, Calif., plant (below). The expansion at Modesto is based on a new process that has resulted from years of research.



Expansion plans are already in the works for the still-under-construction mercury cell chlorine-caustic soda plant of the Solvay Process Division (Allied Chemical) at Brunswick, Ga. When initial construction is completed late this year, the capacity will then be doubled in the second step which should be ready by late 1957. □

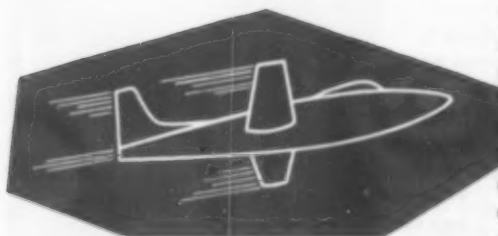
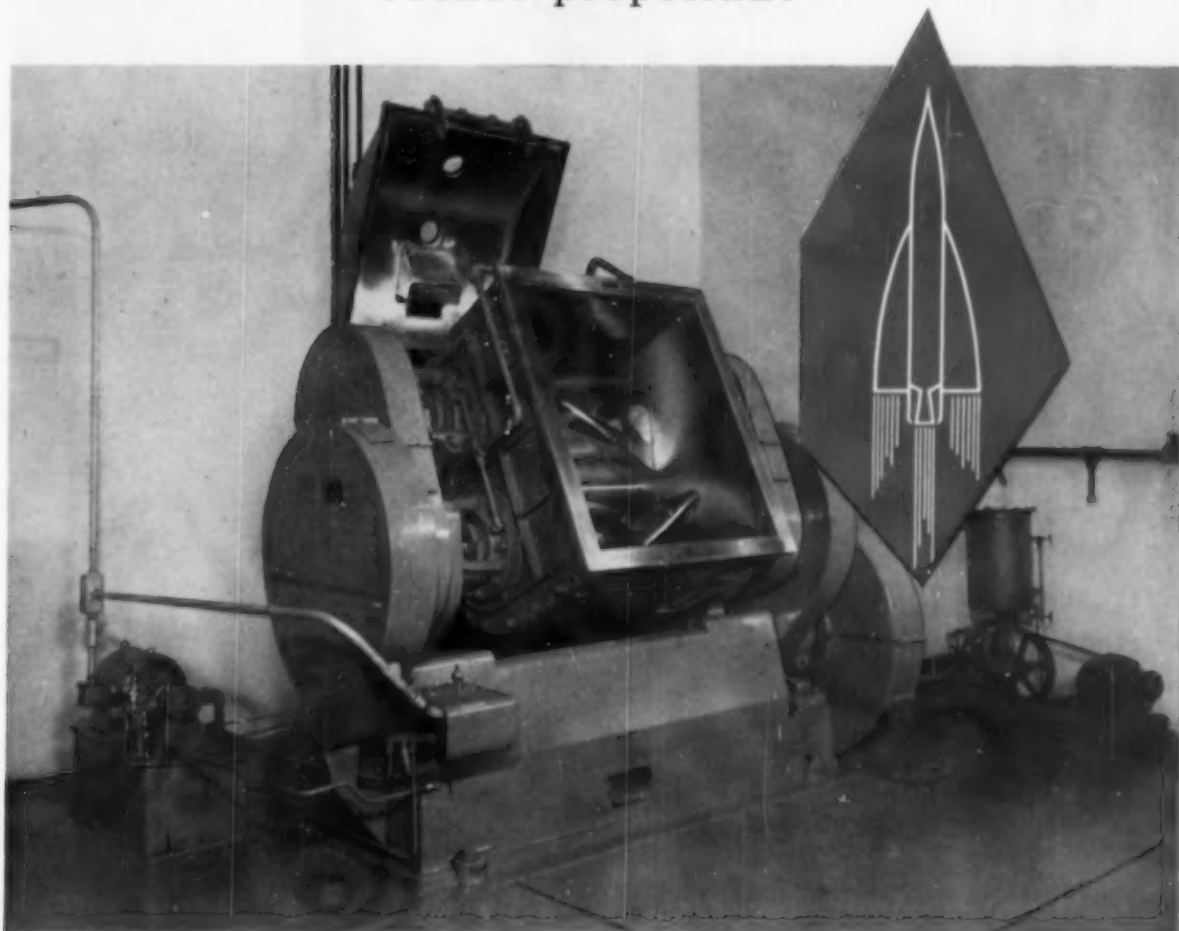
Third major producer of caprolactum nylon-6 in this country will be the Foster Grant Co., which expects to be on stream with its million-dollar Leominster, Mass., plant by the spring of 1957. □

A 100% increase in the production capacity of special clay products widely used in the chemical and process industries as carriers, diluents, bleaching and filtering clays, and coagulants, is now underway at the processing plant of The General Reduction Co., Macon, Ga. □

TURN FOR MORE NEWS ON

| | |
|---------------------|-----------------|
| INDUSTRY | page 54 et seq. |
| OVERSEAS | page 78 |
| NUCLEAR | page 80 |
| INSTITUTIONAL | page 88 |

Thiokol® Chemical Corporation selects
BAKER PERKINS mixers for processing
rocket propellant



Baker Perkins Inc.
Chemical Machinery Division
Saginaw, Michigan

The mixing of rocket propellant from new high-energy fuel materials is a sensitive, highly demanding operation. The mixers which do this blending must therefore be not only efficient, but dependable. The Baker Perkins No. 15 Mixer shown here is but one of many in operation in the rocket propellant field. This unit at the Thiokol Chemical Corporation is enclosed in an explosion-proof room of reinforced concrete, and is engineered for complete remote control operation. Powered by a 50 H.P. silent chain drive motor, the No. 15 Mixer is constructed of Stainless Steel, and jacketed to carry 125 psi pressure of steam or water. Its Sigma blades revolve on anti-friction bearings, hydraulic tilt is provided for the mixing chamber, and the vacuum cover is pedestal mounted. Working capacity of this mixer is 100 gallons, and total capacity 150 gallons. If you have a process that calls for a high-performance mixer, write Baker Perkins for complete catalog.

333



Unibestos...the only single-layer pipe insulation that provides positive protection at the joints

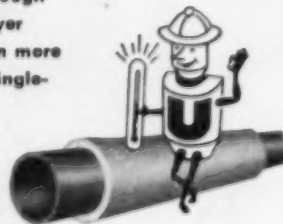
Unibestos is the only single-layer pipe insulation that's built with the strong, long interlacing fibers of Amosite, the quality asbestos from South Africa. This unique construction permits single-layer Unibestos to form positive heat seals at hard-to-insulate joints and fittings...to provide more protection against heat loss than other single- or even double-layer insulations.

With Unibestos on the job, there is less shrinkage...more resistance to moisture, acid and chemical fumes...greater toughness to withstand shock and vibration. Easy to miter, easy to cut, this durable insulation goes on the most complex pipeline systems quickly and economically.

Fast, low-cost application...long-lasting, positive protection—these are the reasons why Unibestos is becoming the specified insulation for more and more of today's industrial operations. Unibestos® is available in sectional form through 44" O.D.

Joe Bestos says:

Remember when insulating these tough fittings, single-layer Unibestos locks in more heat than other single- or double-layer insulations!



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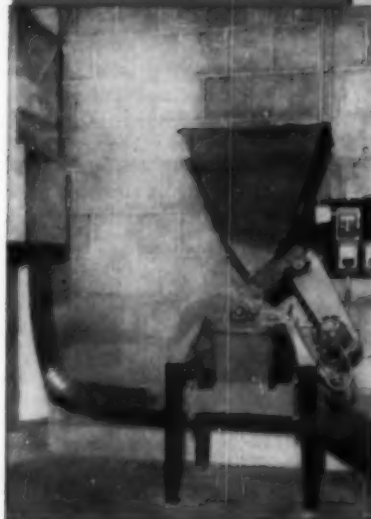
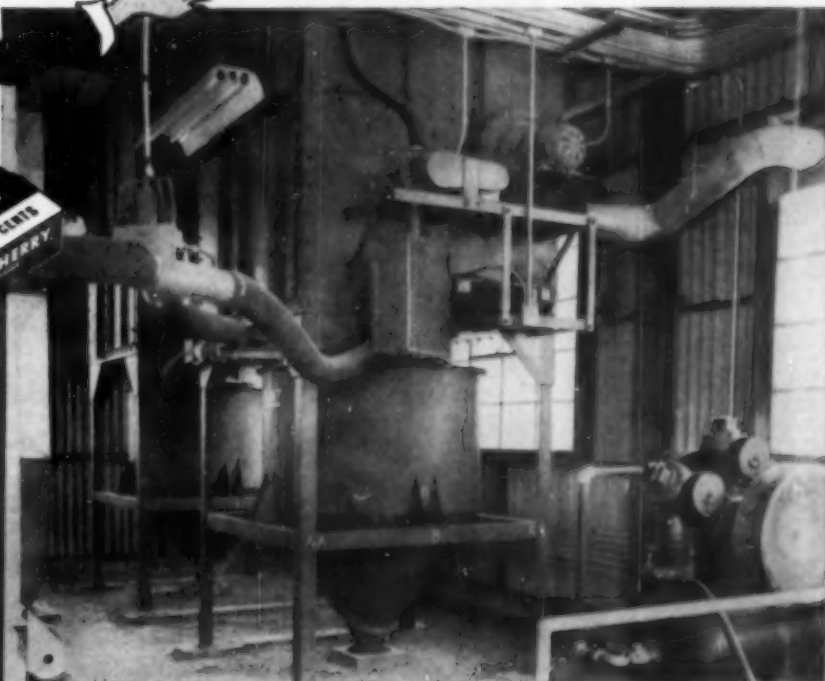
A smoother operation

for a smooth throat-saver



Ducts bringing pulverized material to two MIKRO-COLLECTORS, each with its individual storage bin to hold material for following processing step.

MIKRO-PULVERIZER grinding materials for Pine Bros. Cough Drops at Life Savers Corporation Port Chester, N. Y.



For many years Pine Bros. Cough Drops have been well-known on the counters of many a store throughout the country—where the attractive display of their various flavors has offered a soothing, soothing treatment for the person with a tickly throat.

Today, several processing steps of this division of Life Savers Corporation, have likewise been smoothed out. For here, a brand new MIKRO-PULVERIZER has been installed feeding to two likewise new MIKRO-COLLECTORS.

The problem was one of pulverizing, conveying and providing storage of the ground material of the two MIKRO-COLLECTORS. In this way, material is ground at the rate of 2,000 lbs. per hr. and conveyed a distance of 55 feet to the storage area. Conveying and storing is remotely controlled by means of solenoid valves run by one man at a control panel.

This permits a comparatively short grinding period to store up ample material for the day's operation in the mixers, the next processing step. In addition, a much cleaner pulverizing operation has resulted, with the use of considerably reduced manpower.

If smoothing out and improving a ticklish problem in your operation is in order—a call to the MIKRO Laboratory is a simple first step to arrive at the proper answer. Here, your problem is carefully analyzed—the resulting recommendations can be your guide to a smoother, more profitable operation.

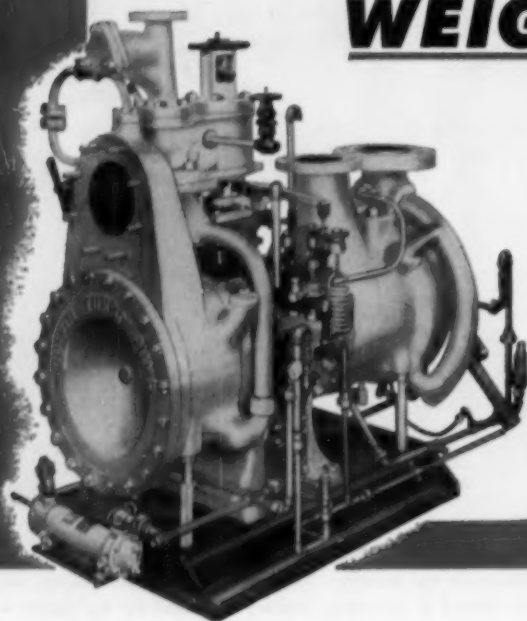
SEND FOR your copy of Bulletin 55, describing the workings of the MIKRO Laboratory, and the MIKRO Test Grinding Data Sheet.

Mikro-D

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Matched pump, turbine and governor are compactly designed and precision built as an integral unit to assure years of dependable performance—in minimum size, with low steam consumption. Widely used for boiler feed service in refineries, chemical plants, paper mills and general industry, the well-known line of Coffin Turbo Pumps offer Volumetric Ranges to 800 gpm, Discharge Pressures to 1500 psig, Steam Temperatures to 950° F., Exhaust Pressures to 200 psig, and Liquid Temperatures to 325° F. For special installations these ratings may be exceeded.

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Representatives in the United States, Canada, Europe, and the Far East

INDUSTRIAL NEWS

ISOTACTIC POLYMERS

(Continued from page 50)

involving a compressed *trans* zig-zag chain.

Key-Catalyst

Evidence, then, is accumulating that the arrangement of the asymmetric centers along a polymer chain has a remarkable influence on the physical properties of the polymer, and that catalysts can exert a high degree of steric control over this arrangement.

Basically, it is reasonable to suppose that the regular configuration of the main chains in these isotactics permits a greater degree of molecular attraction between chains than is possible with random distribution of the asymmetric centers, probably accounting for such properties as higher degree of crystallinity, greater density, and higher melting point.

Literature Cited

1. Natta, G., *J. Polymer Sci.*, **16**, pages 143-154 (1955).
2. Natta, G., et al., *J. Am. Chem. Soc.*, pages 1708-1710 (March, 1955).
3. Levene, P. A., and A. Wohl, *J. Biol. Chem.*, **263**; **75**, 325 (1927).
4. Price, C. C., and L. E. St. Pierre, presented at 128 meeting, Am. Chem. Soc., Minneapolis (September, 1955).
5. Pruitt, M. E., and J. M. Baggett, U. S. Patent 2,706,181 (April 12, 1955).

A \$14 million petrochemical plant is now being built by Southern Nitrogen Co. at Savannah, Ga. The plant will go on stream in early 1957, will produce 250 tons per day of ammonia to be used to make nitrogen solutions and ammonium nitrate. □



This stainless-steel tank at Mississippi Chemical Corp.'s Yazoo City ammonium nitrate drilling plant has made operations considerably more flexible. Built by Chicago Bridge & Iron, the tank has a capacity of 25,000 bbl. It serves two main purposes: to store ammonium nitrate in liquid form during periods of partial plant shut-down and also to store it in the off-season so that it can be processed quickly in the high demand season.

CHEMICAL COMPANIES JOIN IN RARE EARTHS OPERATION

Growing importance of rare earths and heavy minerals in the chemical and atomic industries is reflected in joint venture of Vitro Corp. and Crane Co.

With a combined investment expected to be some \$6 million by the end of 1956, Crane Co. and Vitro Corp. of America are now in a joint operation to produce thorium, rare earths and heavy minerals from monazite, as well as rutile, ilmenite, zircon and kyanite.

Mechanism of the venture is equal ownership of Heavy Minerals, Inc., its mining subsidiary Marine Minerals, Inc., and associated operations. A minority interest will be held by a subsidiary of the French chemical group, Pechiney, and Heavy Minerals will have exclusive North American license to numerous French-held patents on the processing of thorium, rare earths, and heavy minerals. New plant will be in Chattanooga, Tenn.

Main attention will be given to monazite, a major source of thorium and uranium, with the immediate objectives of producing thorium and rare earth components for use in the chemical, metallurgical, and glass industries.

But the key is the future potential of the operation, with extensive research and development work planned. The company's monazite is unique in that it contains the heavier of the rare earth elements such as europium, gadolinium, thulium, and dysprosium, all of which are expected to have important uses in atomic reactors and related equipment. Gadolinium, for example, which sells at present for some \$600 per pound, has 44,000 barns/atom, by far the greatest neutron absorption cross section of any element. Where weight and bulk are critical problems, so that a thin sheet is priceless (say in submarines, aircraft, etc.) gadolinium can be highly useful.

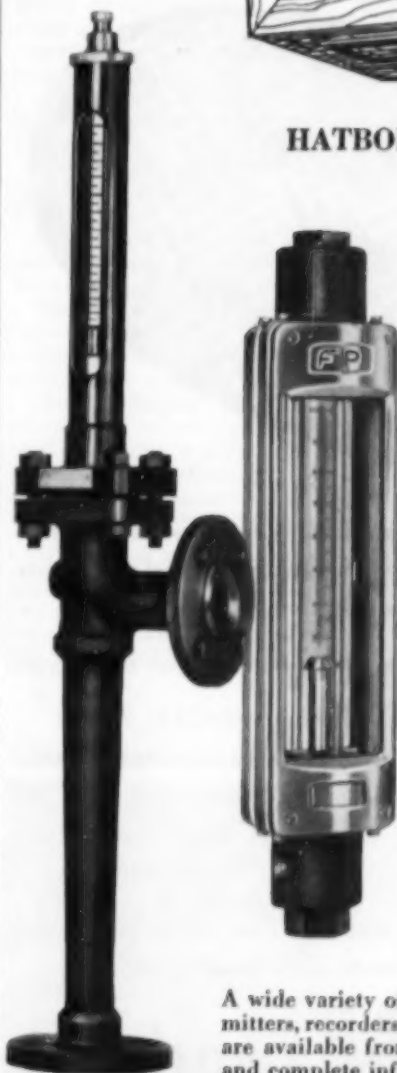
Another group of rare earths from monazite—cerium, lanthanum, neodymium and praseodymium—have strong potential industrial use as catalysts and alloying agents in the production of magnesium and other light metals.

A 2,500 bbl./day fluid catalytic cracking process unit and gas recovery facilities, a catalytic polymerization process unit and light hydrocarbon and gasoline treating equipment, will be built by Procon, Inc., Des Plaines, Ill., for United Refining Co. of Warren, Pa. Work is underway, will be completed this winter. Cost will be over \$2 million. □

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Predictable performance floats permit Flowrator Meters with true percentage scales to be carried in stock. You benefit from F&P's years of hydraulic research by getting accurate meters quickly.

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Advantages of specifying F & P Meters:

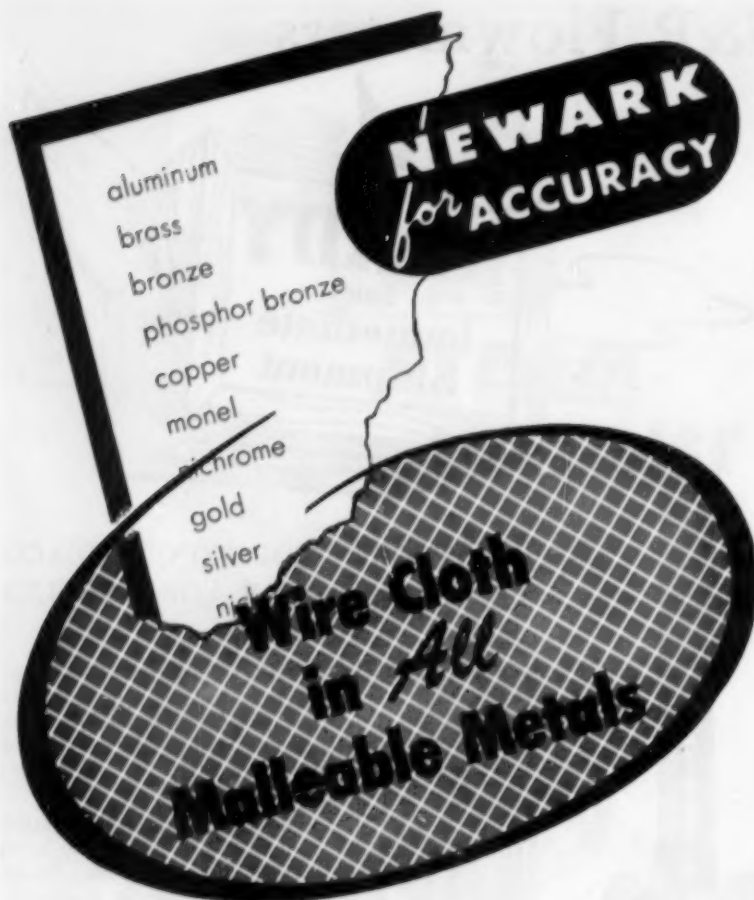
- Highest quality—same as made-to-order, extended shipment instruments.
- Prompt delivery—most items shipped the same day the order is received.
- Economy—standardization on percentage scales and interchangeable parts, minimizes spare part problems.

A wide variety of flow indicators, purgemeters, transmitters, recorders, controllers and pressure instruments are available from stock. Write today for Catalog #2 and complete information.

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In all metals, Newark Wire Cloth is accurately woven in a wide range of meshes, ranging from very coarse (4 inch space cloth), to extremely fine (up to 400 mesh). Our reputation for 'Accuracy' through more than 75 years is your guarantee of wire cloth quality.

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INDUSTRIAL NEWS

NEW EQUIPMENT FEATURES FATTY ACID PLANT EXPANSION

Expanded facilities for the production of high purity fatty acids will include a new radiant heating furnace and stainless steel vessel.

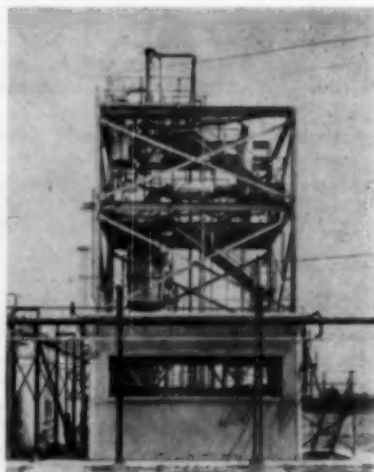
Incorporated in the additional facilities being constructed for the HumKo Company's Chemical Division (formerly Trendex Division) are two significant modifications in equipment for fatty acid distillation.

Rather than employ a conventional direct fired, brick lined furnace with cast iron vessel, a unique, new radiant heating furnace and stainless steel vessel will be installed. The radiant fired furnace, developed by Blaw-Knox, is being used for the first time in this industry, and is particularly suitable for processes requiring close temperature control.

Use of this type of furnace makes the stainless steel vessel practical and highly advantageous, with its better heat transfer and corrosion resistance to eliminate contamination and minimize maintenance.

With this new concept in fatty acid distillation, HumKo expects the furnace and stainless steel vessel to give more accurate temperature control, significant fuel savings, rapid heating and cooling, low initial investment, and low maintenance.

The additional facilities are planned to aid HumKo to meet the increasing demands for high purity fatty acids, and will supplement a continuous still erected in 1954.



New distillation unit will supplement this continuous still at HumKo, new equipment will increase efficiency of company's operations.

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.



Published by The Pfaudler Co., Rochester, N. Y.

Get continuous centrifuging in your continuous processes

For continuous removal of solids from one or two liquids . . .

For continuous concentration of solids by removal of liquid from slurries . . . and discharge of solids in a predetermined dry state . . .



It is no longer necessary for your centrifuging to be an expensive and time-consuming "batch" type operation.

While rotating at full speed, the Titan Superjector Centrifuge discharges solids deposited within the centrifugal bowl and thus cleans itself.

How it works

A simple yet unique design enables the Superjector to work automatically like no other centrifuge.

Solids are discharged through peripherally placed slots. These slots periodically are opened and closed by a telescopic action actuated by hydrostatic pressure. This pressure is built up by centrifugal force.

The concentration of solids and clarity of liquid produced can be adjusted within wide ranges. Solids can easily be concentrated to as low as 40% moisture content. Liquids can be rendered crystal clear.

If you can see uses for such an automatic centrifuge in your operations, write for your free copy of Bulletin No. 930, "Titan Superjector Centrifuge." Or ask your Pfaudler representative for details.

Now—fastest drying of corrosive products with Pfaudler dryer-blender

How do you go about drying highly corrosive products in your plant?

If you're not using a Pfaudler conical glassed steel dryer-blender you may be spending too much time and money on this process.

4-day drying yield ready in 7 hours... reported one user making product containing acid halides. Filling and emptying the Pfaudler conical glassed steel dryer-blender is quick and easy. It has a 1½ foot diameter opening for filling and a single 8 inch discharge nozzle for the 4 ft. and 6 ft. units.

Most of the labor cost and time previously spent handling trays of vacuum dryers is saved.

When in use, the dryer slowly revolves, tumbling its contents and quickly providing an evenly blended, evenly dried product.

These structural features built into the unit make it your fastest and most economical tool for drying and blending highly corrosive products:

- Solid one-piece construction of inner vessel for maximum strength, greatest corrosion resistance and easiest cleaning.
- Space between inner vessel and spherical portions of jacket heads insures effective drying with no waste of heat.
- No joints or clamps to break up the drying surface area. This heated surface area is maximum; therefore drying time is shortest.



At Eastman Kodak Company this Pfaudler dryer-blender, used for drying a corrosive organic halide, has reduced time required by previous methods (4-6 days) by 75%.

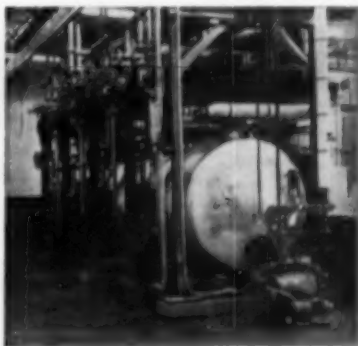
• Vacuum exhaust tube is located up and out of the product while the unit is in operation. There it is able to remove vapors most efficiently.

Dries acids and alkalis

You can use Pfaudler conical dryer-blenders for every acid except hydrofluoric and for alkalis up to pH12 at 212° F. Thus you get the same flexibility you are already familiar with in Pfaudler glassed steel reactors.

These dryers range in volume up to 165 cu. ft. working capacity. They are available in four different diameters: 2 ft., 4 ft., 6 ft., and 8 ft. Internal pressures may range from full vacuum. Each unit is tested to meet ASME code specifications. Write for Data Sheet 26.

How Sylvania heats, cools four separate solutions to $\pm 1^\circ$ accuracy... in one system



The problem at Sylvania Electric Products, Inc. was to find a system that would hold four different solutions to within 1° F. of a predetermined temperature. These solutions may be required for use between 55°

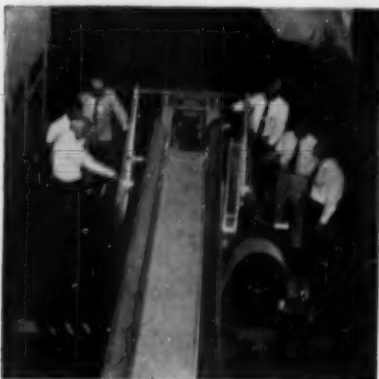
and 70° at any time, and are supplied at anywhere from 38° to 78° F.

Thus, the system must either heat the solution or cool it. It must also vary the degree of heating or cooling. It must switch from heating to cooling, depending on change of set point.

Now in operation at Sylvania's Seneca Falls, N. Y. plant is the Pfaudler system shown (left). It does all the thermal gymnastics mentioned, and still holds to within 1° accuracy on all four solutions.

This system, completely designed and equipped by Pfaudler, includes heat exchangers, all control valves, the heating equipment, refrigeration equipment, automatic controls, panel board and all auxiliary equipment. It is typical of the type of project engineering Pfaudler now offers.

here and there with the **CEP CAMERA**



ARS DIFFERENTIATOR—Conveyor belt projects cottonseed-trash mixture 120 mi./hr.; the seeds which travel furthest are highest quality oil producers.

ROTARY HORIZONTAL VACUUM—filter arranged for countercurrent washing extractive meats of oil-bearing seeds & beans. Used for development of U.S.D.A.-A.R.S. Filtration-Extraction Process for cottonseed, on which Blaw-Knox is collaborating for wider commercial application. L. to R., E. Fred Pollard, & H. L. E. Vix, So. Reg.; Hal B. Coats, Blaw-Knox; E. A. Gastrock, host, So. Reg.; C. F. Hauck, Blaw-Knox; J. J. Spadaro, So. Reg.



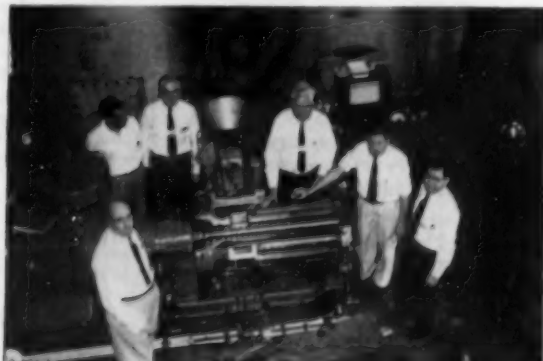
AT SEA WITH THE A.F.C.A. ►

NEW ORLEANS PICTURES

◀ **A VISIT TO SOUTHERN REGIONAL LABS**—During New Orleans Meeting, So. Regional played host to plant trips group. Next day, C.E.P. visited and photographed ARS differentiator (left), rotary horizontal filter (left lower), and kneader (right lower).



Below, group at continuous kneader. Cottonseed meats, flaked or whole, are fed to screw. Pigment glands are ruptured, eliminating toxicity, improving oil quality. After extrusion, moisture is reduced and oil extracted.



PLANT TRIP: The entire A.I.Ch.E. meeting group that made the plant trip through the Esso Baton Rouge Works during the New Orleans National Meeting. Photo courtesy Esso.

AT SEA WITH THE A.F.C.A. was an unusual experience for more than 300 chemical industrialist members and guests of Armed Forces Chemical Assn., June 14th. Aboard the carrier Antietam, A.F.C.A.'ers witnessed anti-submarine tactics of a fleet which also included four destroyers, plus a wide variety of helicopters, jet and propeller aircraft. A submarine from New London took part, as did an atomic-attack force of land-based jet aircraft. Outing took place out of Quonset Point, R.I., Naval Air Station. The Navy acted as host for this outing, with Capt. F. E. Bardwell as Commanding Officer of USS Antietam. Left, superstructure scene during landing of planes.

What appears to be horizon line at left center is bow end of carrier deck.



CHEMICAL ENGINEERING DIGNITARIES: Clifford C. Furnas, asst. secy. for Defense (Research & Development), principal A.F.C.A. banquet speaker, with Major General Wm. S. Creasy, Chief Chemical Officer, Chemical Corps, Dept. of the Army, and principal host.



HANGAR DECK SCENE. More than 300 civilians were viewing exhibits when photo was taken. Scene shows plane parking & service area below flight deck.



FLIGHT DECK SCENE, looking toward bow. About 1/3 of carrier length is represented by this photo. S. D. Musselman, director of Engineering for Amer. Mach. & Foundry, is in foreground, other person unidentified.



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Help in solving your corrosion problem is as near as your phone . . . and the number is listed below. Atlas, with a quarter century of experience in solving corrosion problems, helps over 3,000 plants each year to reduce lost time and money caused by corrosion. Atlas is familiar with all types of corrosion problems, from coating small items of plant equipment to the construction of the largest continuous picklers.

Our facilities are geared to help you with on-the-spot technical advice, engineering and design assistance, highest quality corrosion proof materials and construction services to carry the job from beginning to end.

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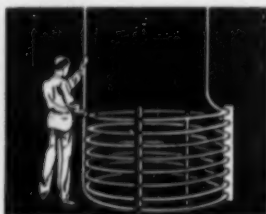
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INDUSTRIAL NEWS

NEW PROCESS MARKS ELECTROMET ENTRY INTO TITANIUM PRODUCTION

Entering the titanium sponge field for the first time, Electro Metallurgical Co., a division of Union Carbide & Carbon, is using new reduction process.

In what is claimed to be the first commercial production of titanium sponge in this country by a method other than the magnesium reduction process, Electromet will produce at a capacity of 7,500 tons per year in its new Ashtabula, O., plant. Largest titanium sponge plant built to date, the new unit marks Electromet's entry into this field.



Some of the equipment at Electromet's new-process titanium sponge plant at Ashtabula, O.

The process at Ashtabula is a sodium-reduction process in which sodium is used to reduce titanium tetrachloride to a metal of high quality. Advantages of the new method, according to Electromet, are both economic and technological. It has been under study, along with other methods, for more than six years at a cost of over \$2 million.

Titanium sponge itself has had a spectacular growth from some 3 tons in 1948 to 7,200 tons in 1955 and an estimated 13,000 tons this year. Electromet expects its new plant to reach rated capacity by late 1956.

The fourth sulfuric acid plant of Stauffer Chemical in California will be built at Dominguez, will cost some \$2 million, will be on stream early in 1957. □

Construction is underway on a \$7.5 million expansion program to double electrolytic production of chlorine and caustic soda at the McIntosh, Ala., plant of Olin Mathieson Chemical Corp. The expansion will increase the plant's capacity to 250 tons of chlorine and 280 tons of caustic soda per day. Construction is being handled by Blaw-Knox, completion expected by January, 1957. □

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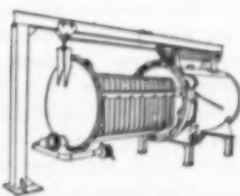
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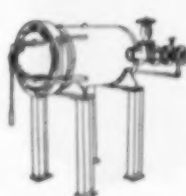
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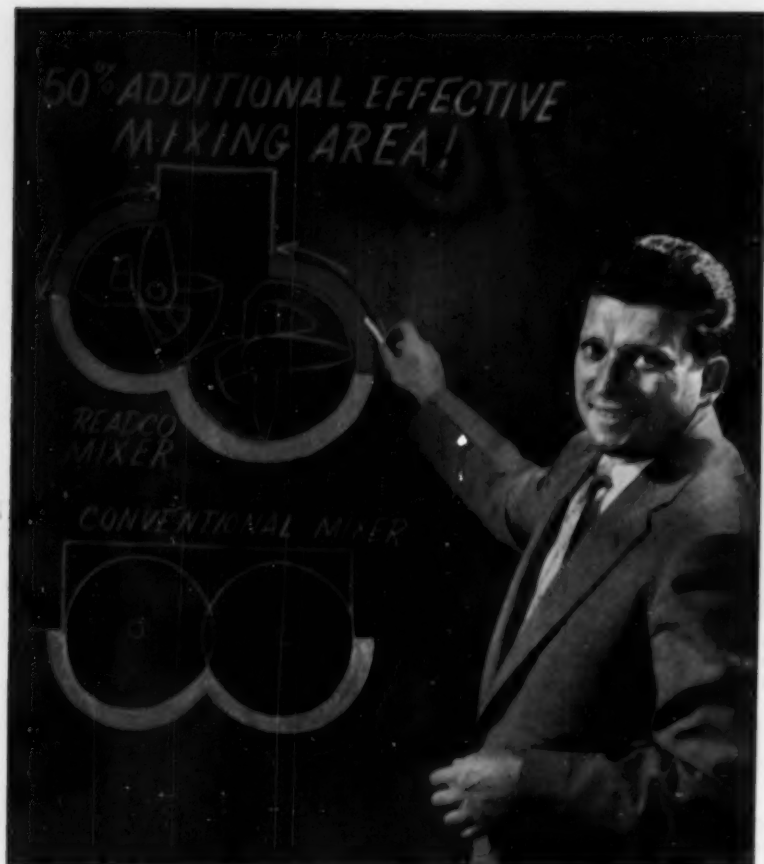


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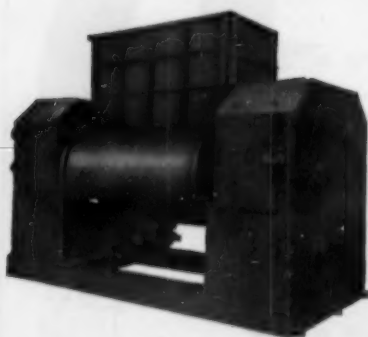
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Photo by Underwood & Underwood



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Readco Paper Coating Mixers can be supplied for manual or hydraulic discharge in 150, 350 and 750 gallon working capacities. Write for complete information.

INDUSTRIAL NEWS

NEW ETHYLENE OXIDE PLANT FOR GENERAL ANILINE

Installation at Linden, N. J. will cost \$8 million, will produce 60 million pounds of ethylene oxide per year.

Expected to go into construction in late August or early September, General Aniline & Film's new plant will also be equipped to produce ethylene glycol of the anti-freeze, industrial and fiber grades, as well as diethylene glycol.

The new installation is an important part of General Aniline's program of expansion in the detergent field and the ethylene oxide from the new plant will be used primarily in the production of the company's own detergents and surfactants.

Scientific Design Co. has been selected to design and engineer the new plant, will use its own direct oxidation of ethylene process. The ethylene will be purchased from the Enjay Co., will be pipelined from the recently announced ethylene facilities of Esso Standard at its nearby Bayway refinery.

The plant is expected to be on-stream in 1957. The ethylene oxide, glycol, and diethylene glycol are also expected to find use in a great many other applications including: cellophane and phenolic resin plasticizers, polyester and alkyd resins, and various industrial chemicals.

Another phase of the company's expansion program in the surfactant field is a new surfactant plant now being built at Calvert City, Ky.

The pure molybdic oxide capacity of Climax Molybdenum will be doubled with the installation of a second sublimation furnace at its Langeloth, Pa., plant. Present production is 2,700,000 pounds a year, the new capacity is already under construction with early September as the expected completion date. □



A new plant to mine and process Fuller's Earth has been put into operation in southwest Georgia by Waverly Petroleum Products Co., Philadelphia. Main use of Fuller's Earth in the petroleum and chemical industries is to make oil and grease absorbents. The plant will also produce, in the near future, fillers for chemical users, carriers for insecticides, slurries for drilling oil wells and filter materials for chemicals and oil.

PROCESS DEVELOPED FOR COMMERCIAL PRODUCTION OF PERCHLORYL FLUORIDE

Pennsalt will become the first commercial supplier of the powerful fluoride oxidizing agent through a production process on which patents are pending.

Discovered in 1952, perchloryl fluoride is a powerful oxidizing agent still in the process of study for properties and applications.

A colorless gas, perchloryl fluoride is thermally stable even when heated to the softening point of glass, but will support combustion as readily as pure oxygen. Not hydrolyzed by hot water, and only slowly decomposed by alkali solutions, its oxidizing action is increased at high temperature. It is non-incendiary and can be safely stored, yet combustible materials will burn in it.

The new compound has many potential applications, in Pennsalt's view, particularly in the production of new explosives and new chemicals. While the compound is still under study, and no plant has been built, the new compound promises to be of considerable importance to the process industries in the future.

A 75,000 ton/year capacity styrene plant will be built by Firestone at Orange, Tex. The company will use the styrene in making its synthetic rubber. □

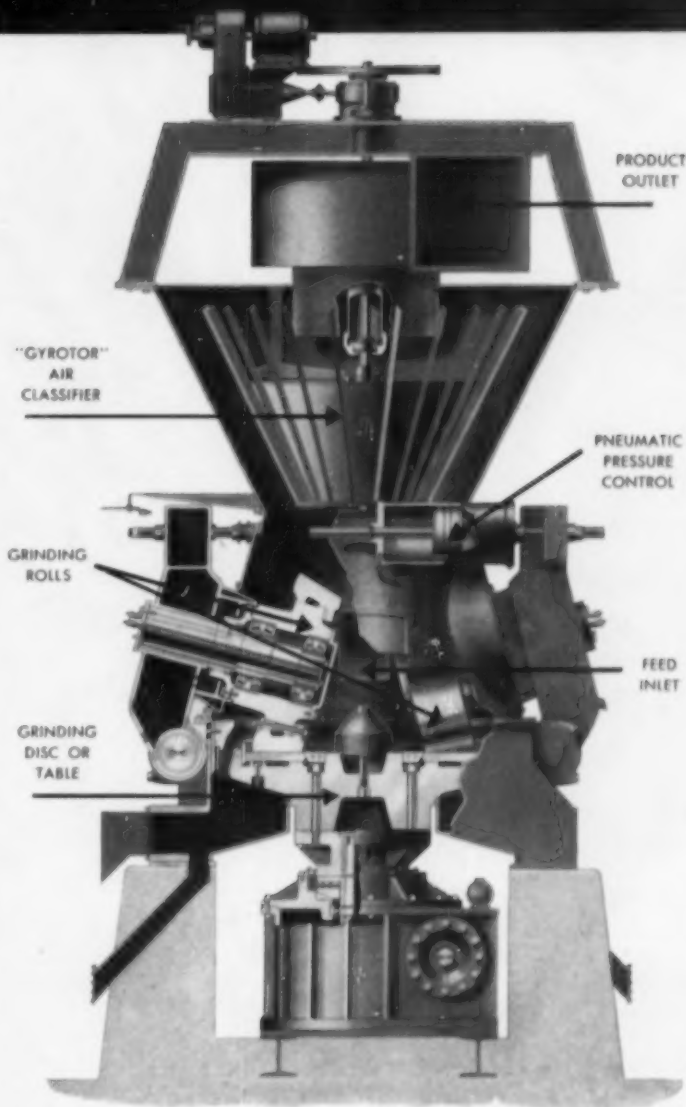
Expansion now under way will increase by 50% the vinyl resin capacity of General Tire & Rubber's Ashtabula, O., chemical plant. Present capacity is 25 million pounds annually. □

A magnesium bisulphite pulping and chemical recovery process will be installed at the Berlin, N. H., plant of the Brown Co., under license from Babcock and Wilcox. This will be the first "MgO" installation in the eastern part of the U. S. to recover both the chemical and heat values in waste sulphite liquor. □

Low-pressure polyethylene plant with annual capacity of about 40 million pounds will be built by Celanese near Houston, Tex. The plant will use the Phillips process, will be completed during the first quarter of 1957. □

Major new plant addition will be ready for use in July at Automatic Control Co.'s St. Paul, Minn., plant for the manufacture of the company's precision liquid level and pressure control systems. □

DISC-ROLL MILL



The Hardinge Disc-Roll Mill is a roller-type mill with two adjustable, pneumatically loaded rolls for grinding material on a horizontal rotating disc or table (Loesche type). The Hardinge "Gyrotor" Air Classifier, in combination with the mill, provides a complete grinding, classifying, and drying system. A full description is given in Bulletin 52-40.

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| 38L | 39A | 40A | 41A | 42A | 43A | 44A | 46A | 47A | 51A | 52A | |
| 53A | 54L | 55R | 56L | 57A | 59R | 60L | 61A | 62L | 63R | 64A | |
| 69A | 72TL | 72BL | 73R | 74L | 75R | 76L | 77R | 78L | 79R | 80L | |
| 81R | 82L | 86L | 86R | 87R | 88TL | 88BL | 89R | 90TL | 90BL | 91TL | |
| 91BL | 91R | 93R | 94L | 94R | 95R | 96TL | 96BL | 97R | 99L | 99R | |
| 100L | 101TL | 101BL | 101R | 102TL | 102BL | 103L | 103R | 104L | 105TL | 105BL | |
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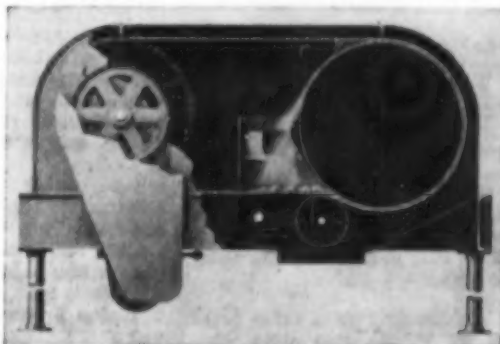
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GUIDE

to significant developments in

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developments of the month-



61 Drum-Type Dryer. Called Drumulator, unit is used for batch or continuous drying of feeds ranging from pasty or doughy mixes to granular material. Material is dried in the space between the heated surfaces of the drum & belt. Material is forced across the drum face by continuous introduction of new feed material. It is in contact with the drum for two-thirds of a revolution—then plowed off & again fed to the drum. Repeated plowing off & return of material is said to agitate & mix it, improving moisture release & presenting new material to the drum's face.

Material advances across drum face a fraction of an inch each revolution. Drying is complete when material has traversed width of drum & is plowed off into discharge chute.

Steam heated drum is designed for maximum operating pressure of 150 lb./sq.in. Gas, oil, hot air or hot water can be used. Advantages cited are: no heavy foundation required & minimum floor space; completely enclosed & easy to clean; eliminates need for crushing after drying; handles material previously dried only on tray dryers. Jeffrey Mfg. Co.

(Continued on page 66)

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3R Rotary Sifter. B. F. Gump Co. Bar-Nun rotary sifters available with from 2 to 76 sq.ft. of screen surface. With optional flows provide smooth, trouble-free performance.

4A Mixers. Eastern mixers available in types to satisfy all conditions of fluid consistencies & tank sizes. Wide range of horsepower, speed & construction materials. Bulletins, Eastern Industries, Inc.

6A Package Pump. The new Verti-Line package pump available for wells as small as 4 in. Two through 7½ h.p. Capacities to 7,500 gal./hr. Bulletin available. Layne & Bowler Pump Co.

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10L Cooling Towers. The close alliance between end product & consistent cold water temperature demands proper tower performance. Marley Co. design for continuous top-level performance.

11A Gyrotory Screen. New in design, performance, & economy, a gyrotory screen from Allis-Chalmers. Stainless steel construction & wide sizing range. Literature available.

12A Alloy Products. Where rugged service is required solid stainless does the job. In some cases stainless cladding may do the job. Consult Sun Shipbuilding & Dry Dock Co.

13A Refractometer. An accurate automatic indicator of changes in composition by continuous measurement of refractive index of flowing liquid sample & comparison to a liquid standard. Consolidated Electrodynamics Corp.

14A Reactors. Autoclave Engineers now build plant size reactors with lab-equipment precision. Send for bulletin.

15A Refractory Materials. Exposed only to heat, Carborundum Company's refractories can be used with complete safety at temperatures above 3,000° F. Ask for "Refractories" the magazine in which heat resistance is thoroughly explored.

16A Packless Valves. Valves for nuclear service built with painstaking quality control by The Wm. Powell Co. Three types illustrated for use with heavy water, molten metals, etc.

17A Impervious Graphite. Called Karbate & used for fabrication of process equipment this graphite said to cost less & last longer. Literature from National Carbon Co.

18A Tubing. A wide range of sizes & alloys in top quality instrument tubing available from Superior Tube Co. Send for guide to selection & application of this tubing.

19A Chemical Porcelain. Insure the safety of your maintenance lines by using Lapp Insulator Co. Tufclad. This solid chemical porcelain is armored with fiberglass-reinforced plastic.

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25A Cooling Coil Unit. From Allis-Chalmers a cooling coil insulated from the tank. Main arc is confined within the coil, thus preventing arc transfer to the tank.

26A Valves. Valve clinics to determine needs of industry are regular occasions with Cooper Alloy Corp. At area & in-plant meetings their engineers work out

specific problems of users, specifiers, & buyers.

27A Silica Gel. Davidson Chemical Co. pioneered in the first commercially used silica gel. Since then it has led in production of the material & offers wide variety of particle sizes, densities & adsorptive capacities.

28A Bronzes. Five types of Ni-Vee bronzes are the products of International Nickel Co., Inc. Ask for booklet "Engineering Properties and Applications of Ni-Vee Bronzes," for complete information.

29A Engineering-Construction Service. If you are considering plant expansion or modernization take advantage of the long experience of the Girdler Co. Consultation available.

30A Process Equipment. Whatever your need in the field of process equipment Whitlock Mfg. Co. is prepared to supply it. In addition to standard equipment they design for specific requirements.

31A Joints & Couplings. Chemical expansion joints & flexible couplings act as insurance for your chemical piping. Ask for catalog for additional information. U. S. Gasket. Belmont Packing Co.

32A Centrifuges. Three types of high capacity automatic solids discharging centrifuges are the product of Sharples Corp. Take advantage of their process laboratory for test purposes.

33A Jet Apparatus. Schutte and Koerting are fabricators of jet apparatus, rotameters & flow indicators, valves, & heat transfer apparatus. For detailed information ask for their bulletins.

34L Tank Car Rupture Disc. A new model TC rupture disc from Black, Sivalls & Bryson, Inc. which will not corrode or fatigue while car is in transit. Adaptable to either standard bolted or threaded type tank car fittings.

35A Process Control. Called CycleLog, a controller from Foxboro Co. which enables establishment of intricate control programs for process variables.

36A Centrifugal Pumps. With 70,480 combinations to choose from Worthington Corp. SESC line allows you to custom-build your pump from stock parts. Insures prompt delivery at low cost.

DEVELOPMENTS OF THE MONTH (Continued)



62 Recording Thermometer. Developed by Pacific Transducer Corp.—a low-cost recording maximum-minimum thermometer. Measures ambient temperature & records both low & high values over given period of time. Features a replaceable paper chart on which a permanent record of temperature is shown. May be quickly replaced & filed for reference. May be used for recording temperatures in ovens, incubators, curing rooms & greenhouses.

(Continued on page 67)

38L Motorpumps. From Ingersoll-Rand Co. pumps designed for deliveries of 5 to 2,800 gal./min. Operate in any position. Sizes 1/4 to 75 h.p.

39A String Filter. One of the many types of filters made by Filtration Engineers Inc. Improves filtration on jobs ranging from thick fibrous cakes to thin sticky slimes.

40A Mixer. An efficient & versatile unit for mixing solid propellants for rockets & other uses. Heat transfer is direct & positive. Bramley Machinery Co.

41A Process Equipment. M. W. Kellogg Co. long a leader in the design & fabrication of petroleum & petrochemical equipment is prepared to use their knowledge to your advantage.

42A Lithium. Lithium's uniquely valuable differences in organic & inorganic chemistry, metallurgy, & heat transfer resey investigation. Lithium Corporation of America, Inc.

43A Ion Exchange. To increase yields, simplify flow sheets & cut labor costs when used with other hydrometallurgical processes use ion exchange. Information available from Permutit Co.

44A Iso-Plus Process. Combines proved advantages of catalytic Houdriforming with other process resulting in practical approaches to higher octanes at low investment cost. Houdry Process Corp. Information available.

46A Plastic Tubing. Recommended reading for design engineers is the booklet "Tygon Tubing," issued by U. S. Stoneware Co. Gives complete & detailed information on the subject.

262A Stainless Steel Plates. When in the market for stainless steel plates, plate products, forgings, bars & sheets contact G. O. Carlson, Inc.

47A Filters. Engineering special adaptations of standard filters to meet particular requirements is continuous with Sparkler Mfg. Co. Specialists in filters for food, pharmaceutical, petroleum & other industries.

81A Mixers. Illustrated is the No. 15 Baker Perkins Inc. mixer for special use in mixing of rocket propellant for high-energy fuel materials. Constructed of stainless steel, unit is powered by a 50 h.p. silent chain drive motor. Catalog available.

(Continued on page 68)

DEVELOPMENTS OF THE MONTH (Continued)



63 Joining System. Method for efficient joining of Unitrace sections has been introduced by Aluminum Company of America. Unitrace is an integrally extruded steam traced aluminum pipe & the new system involves a special cast flange made in alloy A356-T6. Features a built-in product & steam tracing line. When joining two sections, trace lines are cut back approximately 2 1/2 in. from the ends of the sections to be joined. Flanges are then slipped on to each section end. Sections & flanges are welded at front faces & necks of flanges using 4043 weld wire. Advantages: prevention of "freezing" of product between sections.

(Cont. on page 68)

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

CHEMICAL ENGINEERING PROGRESS

25 West 45th Street

New York 36,

New York

BUSINESS REPLY CARD
First Class Permit No. 48870, Sec. 34.9, P. L. & R., New York, N. Y.



CHEMICAL ENGINEERING PROGRESS

25 West 45th Street

New York 36,

New York

BUSINESS REPLY CARD
First Class Permit No. 48870, Sec. 34.9, P. L. & R., New York, N. Y.

products-(Cont.)

advertised in this issue

52A Pipe Insulation. Called Unibestos & said to be only single-layer pipe insulation, material provides positive protection at the joints. Built with strong interlacing fibers of Amosite. Union Asbestos & Rubber Co.

53A Pulverizing & Conveying Units. Mikro-Pulverizers & Mikro-Collectors are the products of Pulverizing Machinery Div., Metals Disintegrating Co., Inc. Bulletins available on the Mikro Laboratory & Mikron test grinding data sheet.

54L Turbo Feed Pumps. An integral unit results from matched pump, turbine & governor in minimum size with low steam consumption. Widely used for boiler feed services. J. S. Coffin, Jr., Co.

55R Flow Meters. Predictable performance floats permit flowmeter meters with true percentage scales to be carried in stock. Fischer & Porter line includes many other types of metering units.

56L Wire Cloth. Made of all malleable metals in many meshes you are enabled to select one cloth to meet your conditions of corrosion and/or contamination. Newark Wire Cloth Co. Catalog available.

57A Process Equipment. Read the quick facts about the services & equipment Pfaudler Co. has available to aid you in reduction of corrosion & processing costs. Literature available.

59R Corrosion. Help in solving your corrosion problems available from Atlas Mineral Products Co. Facilities are geared to help with on-the-spot technical advice.

60L Tantalum. An attractive material of construction because of its immunity to acid attack, it has excellent heat transfer properties & is not damaged by thermal shock. Ask for booklet. Fansteel Metallurgical Corp.

61A Process Filters. Illustrated are some of the filters in the line of Process Filters, Inc. Units said to be trouble-free & to operate with profit.

62L Mixer. Read Standard Corp. Improved mixer design provides complete dispersion in less time at less cost. Has a greater ratio of surface to volume of mix.

63R Disc-Roll Mill. This is a roller-type mill with two adjustable, pneumatically loaded rolls for grinding material on a horizontal rotating disc or table. Gyrotor air classifier, combined with mill provides complete system. Bulletin. Hardinge Co., Inc.

64A Nitric Acid Plant. If you are building new nitric acid production facilities call on Fluor Corporation Ltd. licensed to design & construct such plants.

69A Laboratory Spray Dryer. The Bowen Engineering, Inc. conical laboratory spray dryer features an interchangeable nozzle or wheel atomization, providing extreme operating flexibility. Capacity 15 to 80 lb./hr.

72TL Laminates. For corrosion resistance, for electrical insulation cut costs by using Carl N. Beetle Plastics Corp. glass reinforced polyester, epoxy, phenolic laminates.

72BL Jet Mixer. Unit affords extremely good agitation & mixing without entrapping air. Send for folder. Hermes Machine Co.

73R Vertical Pumps. Lawrence Pumps Inc. fabricate vertical pumps with no submerged bearings for pumping abrasive corrosive slurries. Full details available in Bulletin 203-6.

74L Kiln Flights. Knowledge of how to use several alloying elements to advantage in the fabrication of these kiln flights brings out special characteristics & solves all corrosion problems. Duraloy Co.

75R Heat Exchangers. To be efficient, heat exchangers should be designed for the job they do. Industrial Filter & Pump Mfg. Co. offer a complete design & manufacturing service.

76L Process Equipment. Falls Industries Inc. employ impervite graphite to fabricate their line of process equipment. Information available on each product.

77R Conveyor Dryers. Built to specifications determined by experience gained through years of specialization National Drying Machinery Co. units incorporate many exclusive developments. Folder available.

78L Heat Exchangers. Facilities of Downtown Iron Works, Inc. are available to turn out your corrosion-resistance exchangers in materials of your choice. Ask for Bulletin HE.

79R Centrifuges. Modern continuous chemical processing units available from Centrico, Inc. are the product of Westfall Separator A.G. For use in the chemical, pharmaceutical, food processing & oil industries.

81L Heat Transfer & Process Units. Illustrated are but a few of the Manning & Lewis Engineering Co. products. Designed for quality performance.

82L Liquid Coolers. From Doyle & Roth Mfg. Co., Inc., packaged liquid coolers for water, oils, gases, & other liquids. Package includes complete refrigeration cycle plus other parts. Sizes 5 to 100 ton refrigeration.

86L Woven Wire Screens. Available in all corrosion-resistant metals & designed for long life & better service, woven wire screens from Cleveland Wire Cloth & Mfg. Co. Write for bulletins.

86R Product Data. Whether your need is to know about motors or other units turn to Chemical Engineering Catalog to quickly find the answers you need. Reinhold Publishing Corp.

87R Flexible Ball Joints. Now available in sizes from 2 through 6 in., in a variety of types, Barco Mfg. Co. steam jacketed flexible ball joints handle sulfur, asphalt & other materials efficiently. Catalog.

88BL Spray Nozzles. Binks Mfg. Co. line of spray nozzles contains a size & spray pattern for every purpose. Information available on nozzles & cooling towers.

88TL Fittings & Flanges. Unplasticized PVC fittings made by the Hendry process are available from Tube Turns Plastics, Inc. Good corrosion resistance. Handles most chemicals to 165° F. Booklet.

89R Mixers. Called Mix-Muller unit specifically designed to give a thorough blend of dissimilar & disproportionate materials. Handbook available. Simpson Mix-Muller Div., National Engineering Co.

90TL Rectifiers. Called Sel-Rex, germanium rectifiers from Bart-Messing Corp. are completely sealed & liquid cooled. No bolting or alignment to bother with. Single units 225 to 50,000 amp.

90BL Gauges. Two types illustrated. Features & other pertinent data listed. Bulletin describes other glassware in line. Kontes Glass Co.

91TL Pump. For use in pumping liquids, gases, slurries without corrosion or contamination. Ask for catalog. Sigmamotor, Inc.

DEVELOPMENTS OF THE MONTH (Continued)



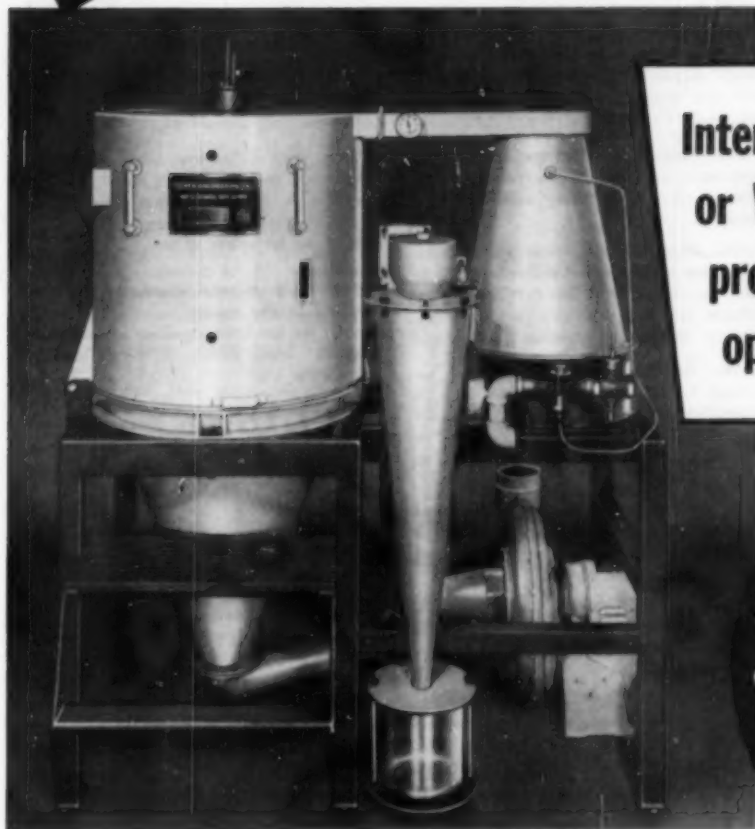
64 Epoxy Adhesive Kit now being produced by Houghton Laboratories, Inc., Olean, New York, is a new development utilizing the outstanding bonding properties of the epoxy resins. Big feature of the Kit is that correct proportions of resin and hardener are contained in two flexible tubes. User need only squeeze two beads of equal length on mixing surface, mix thoroughly, and adhesive is ready for use. Human errors are eliminated and precise mixture for best results is automatically assured. Applications of the Kit are many and various. Epoxy resins make excellent bonds metal-to-metal, metal-to-wood, wood-to-wood, glass, ceramics and other plastics.

(Continued on page 70)

(Continued on page 70)

NEW!

BOWEN CONICAL LABORATORY SPRAY DRYER



**Interchangeable Nozzle
or Wheel Atomization
provides extreme
operating flexibility**

**CAPACITY
15 to 80 lbs/hr
water evaporation
depending on inlet
temperature and
product drying
rate**

The New Bowen Conical Laboratory Spray Dryer has been especially designed for economical product evaluation and production of limited quantities of valuable materials. Particular attention has been given to operating features and ease of cleaning. Surfaces in contact with feed material and product are stainless steel

throughout. Drying temperatures are variable up to 1000°F to accommodate a wide variety of materials.

The New unit can be seen in operation, by appointment, at the Bowen Laboratory in North Branch.

Write for Bulletin 34

Describes the Bowen Conical Laboratory Spray Dryer in detail and gives complete technical specifications.

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

**BOWEN SPRAY DRYERS
Always Offer You More!**

Recognized Leader in Spray Dryer Engineering Since 1926

products- advertised in this issue (Cont.)

918L Vacuum Equipment. From Jet-Vac Corp., steam jet ejectors, vacuum equipment, & condensers.

91R Agitators. Read the long list of features incorporated in Philadelphia Gear Works, Inc. fluid agitators. Bulletin.

93R Expansion Joints. ASME approved & stamped high flexibility joints for shell & fixed tube heat exchangers. Flexibility to ± 3 in. of lateral expansion. Richard M. Armstrong Co.

94L Portable Mixer. To enable you to mix liquids in any container, the Alsop Engineering Corp. portable mixer. Does hundreds of mixing jobs at low cost. Easily adjusted to correct mixing angle.

94R Temperature Control. Claud S. Gordon Co. are manufacturers & engineers of temperature control instruments, thermocouples & accessories & other units.

95R Slime Control. Chlorination of cooling water eliminates heat transfer losses caused by slime formation. Wallace & Tierman Inc. invite inquiries concerning cooling water chlorination.

96TL Laboratory Glassware. Every item in the Diamond D Blue line from Doerr Glass Co. will measure with maximum accuracy & uniformity. Ask for brochure.

96BL Low-Volume Pump. Available from stock a low-cost, low-volume pump from Eco Engineering Co. Capacities 1 to 10 gal./min. Pressures to 150 lb./sq.in. Bulletin.

97R Cone Blender. For fast, thorough mixing investigate the Paul O. Abbe Inc. cone blender. Design insures complete dispersion & mixing.

99L Dryers. Building dryers for highly diverse industries over a period of years enables fabrication of a dependable unit for your product. C. G. Sargent's Sons Corp.

99R Large O.D. Pipe. For specialized uses in chemical plants, & fabricated from variety of materials Posey Iron Works, Inc. fabricate pipe 20 in. diam. & larger. Complete information available.

100L Gages, Valves & Specialties. Jerguson Gage & Valve Co. products are made especially for the chemical & petrochemical processing industries. Ask for data on your needs.

101R Piping, Valves, Ducts, etc. Fabricated from corrosion-resistant polyethylene & PVC components. These fittings have made possible trouble-free handling of corrosive acids, & other materials. American Agile Corp.

101TL Precision Bore Stirrers. Interchangeable parts are featured in stirrers made by Wilmad Glass Co. Parts available from stock.

101BL Flow Indicator. Now available approximate measurement of water flow in gal./min & air flow in cu.ft./min. with Schutte and Koerting Co.'s ball flow indicator. Dual scale for water & air.

102BL Grinders. If your product is required to be pulverized ultrafine with controlled particle size the Schutz-O'Neill Co. unit will do the job. Six sizes 7 1/2 to 125 h.p. with grinding chambers 12 to 28 in. in diam.

102TL Process Equipment. Artisan Metal Products, Inc. design & manufacture a variety of process equipment units as well as pilot & complete plants.

103R Pumping Control. Use of U. S. Motors Varidrives handle variable speed pumping problems in all types of industry. Available in 1/4 to 60 h.p. with speeds 2 to 10,000 rev./min.

103L Pumping Progress Report. A report on how their pumps can do your job. Ask for Data Sheet 67A describing the 6 in. Stroke Direct Flow Series. Aldrich Pump Co.

104L Laboratory Oven. Ace Glass Inc. has recently improved the design of their Blue M ultra modern ovens & made them more convenient & economical to operate. Write for Supplement No. 1.

✓ **CHECK** your Data Service requests on the handy postcard on page 65 to

► **GET up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.**

105TR Gate Valve Line Blind. It is easy to change line blinds with the Greenwood gate valve line blind from Vernon Tool Co., Ltd. No bolts to loosen, no lifting of plates, no spreading of line.

105BL Bulk Material Control. The new Roto-Bin-Dicator mounts outside bin at any angle, for bin level signaling or machinery control. Micro switch in motor housing. Bin-Dicator Co.

105BR Fin & Pipe Coils. Made of stainless steel for handling corrosive air mixtures or liquids to be heated or cooled fin & pipe coils from Rempe Co. Engineering Data Book available.

105TL Spray Nozzles. Performance-proved for every operation spray nozzles from Spraying Systems Co. Actually tens of thousands of nozzles to choose from. Catalog.

106L Silicone Defoamers. Three types available to cut process time & boost production. Eliminate waste & fire hazard of boilovers. Dow Corning Corp.

107TR Proportioning Pump. Called Microflex a chemical proportioning pump with pressures to 60,000 lb./sq.in. & capacities 0.97 to 31.21 gal./hr. Simplex & duplex types. American Instrument Co.

107BR Adjustable Sprocket Rim. Redesignated for greater strength, easier, quicker, more solid assembly, an adjustable sprocket rim with chain guide from Babbitt Steam Specialty Co.

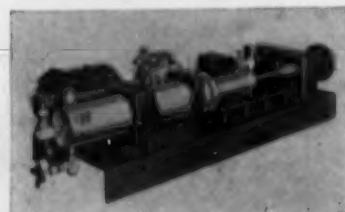
115R Steam-Jet Evactor Units. Chemical processes involving high vacuum evaporation, distillation or vacuum cooling of corrosive materials are opportunities for consideration of Croll-Reynolds Co., Inc. units.

IBC Controlled Volume Pump. Reducing chemical costs & upgrading product quality are problems covered in bulletins on controlled volume pumps available from Milton Roy Company.

OBC Mixers. For the latest mixing information & full description of Lightnin mixers one of the available bulletins from Mixing Equipment Co. will prove useful. For close control of product quality & uniformity.

DEVELOPMENTS OF THE MONTH (Continued)

65 Micro-Feeder. Unit was originally designed to fill need of petroleum industry for highly accurate, low capacity liquid metering instrument. Delivers uniform,



pulsation-free flow at precisely controlled rate, independent of variations in feed pressure or changes in viscosity or vapor pressure of liquid handled. Accuracy $\pm 0.25\%$ of set rate. Reloading is manual—with clutch disengaged, hand wheel may be turned to reload cylinder. Standard equipment includes measuring cylinder assemblies of 316 stainless steel & explosion-proof electrical equipment for hazardous locations. Available in three models with feed rates from 1.0 to 800 cc/hr. & discharge pressures to 2,000 lb./sq.in. gage. Proportioners, Inc.

(Continued on next page)

equipment-

1 Thermocouple Assembly. From Conax Corp. a well illustrated catalog covering a line of thermocouple assemblies & pressure glands. Unique is the Safetywell assembly furnished complete with thermocouple. Offers protective features of closed well combined with high pressure safety seal in the Conax thermocouple gland.

2 Hydraulic Pump Motor. The new spline coupling method of hooking up a hydraulic pump to an electric motor's output shaft eliminates adapter & alignment problems. Installation time about 1/10 of conventional hookup. Reuland Electric Co. spline-coupled hydraulic pump motors are available in ratings 15 h.p. through 40 h.p.; frame sizes 324U & 26U. Single or double end pump installations. Engineering data available.

3 High Pressure Apparatus. Chemtech Products Corp., U. S. representatives of Andreas Hofer for autoclaves, reaction vessels & contact apparatus have available an illustrated catalog of this equipment. Data sheet gives details in addition to that given in book.

4 Welding. Welding repairs & fabrication are considered in a bulletin from Metalweld, Inc. Outlines various processes for repairing broken or worn machinery; structural repairs to other equipment, plus special fabrications from rolled steel plates or slabs for construction purposes. Portable equipment available for in-plant repair work.

5 Line Blinds. Tee & ell type gate valve line blinds designed to simplify piping & manifold installations. Their use permits compact piping arrangement & eliminates surplus fittings. Engineering data & cutaway views in bulletin. Greenwood Valve Div., Vernon Tool Co., Ltd.

6 Entrainment Separators. From Schuyler Mfg. Corp. bulletin on line of entrainment separators for use in petroleum, chemical, food processing, & other industries. Clean, positive liquid/vapor separation in process vessels assured.

7 Control Equipment. A new, well illustrated bulletin from Consolidated Electrodynamics Corp. covers their analog & digital systems, facts for new product development, process control, maintenance of product quality & other areas.

8 Teflon Packings. New bulletin from Raybestos-Manhattan, Inc. on their Teflon packings & gaskets. Illustrates & describes split & folded types of envelope & solid gaskets, Teflon stuffing box, plus various types of valve stem packings. Lists available sizes, properties, & service recommendations.

9 Electric Heaters & Heating Devices. A 60-page binder insert catalog from General Electric Co. devoted to electric heaters & heating devices. Contains application index, calculating data, specifications, operating information on standard G-E units. Included

are immersion, strip, cartridge, tubular, fin heaters, oven equipment & control.

10 Nickel & Nickel Alloy Tubing. A brief but highly serviceable handbook from Superior Tube Co. covers nickel & nickel alloys for use by designers, production engineers & purchasing executives. Tabulates specific mechanical properties & chemical compositions of 13 analyses of nickel & nickel alloy tubing drawn at the Superior mill.

11 Blower. Read Standard Corp. illustrated bulletin on the Standardaire blower. A modern compressor featuring high efficiency, compactness, clean air delivery & many other features. Cutaway views & capacity tables included.

12 Heat Exchangers. Titled "Lummus Standard Heat Exchangers for Process Industries," brochure includes descriptions of the design specifications & construction details of standard units; tables of effective surface area available; dimensional tables & thermal design data with necessary tables. Lummus Co.

14 Water-Cooling Units. Steam-jet units for supplying commercial quantities of chilled water at temperatures as low as 35° F. are covered in a bulletin from Ingersoll-Rand Co. Lists range of sizes available with approximate dimensions. Sizes 30 to 1,200 tons of refrigeration.

15 Water Filters. Pressure type water filters from Graver Water Conditioning Co. are completely described in their new bulletin. Lists uses, design features & engineering details of pressure sand & gravel filters. Also included are details on accessory equipment, types of controls available & detailed table giving capacities, size & space requirements.

16 Flocculation & Clarification Unit. From Dorr-Oliver Inc. a 12-page 2-color bulletin on the Dorrco Clariflocculator, a combination unit which provides flocculation & clarification in a single tank, applicable to treatment of water, sewage, & industrial wastes, in addition to operations in the chemical & process industries. Major advantage is transfer of floc from one chamber to another without disintegration.

17 Tubing & Pipe. Technical data folder from Babcock & Wilcox Co. This binder insert will aid engineers associated with equipment design involving use of tubing at elevated temperatures & pressures. Gives maximum allowable stress values for ferrous pipe & tubing.

18 Porosimeter. A complete pore-structure analysis of any porous material performed in a ten-minute operating cycle by means of the Aminco-Winslow Porosimeter. Measures sizes of pores ranging from 0.1 μ m. to 0.06 microns & pore volumes as small as 0.0005 ml. at each pore diameter. Illustrated bulletin gives details. American Instrument Co., Inc.

19 Temperature Controls. Available from Parlow Corp. a new condensed catalog covering the majority of their temperature controls. Bulletins on individual controls also available.

20 Liquid-Feed Blender. Details of the new Patterson-Kelley Co., Inc. liquid-feed twin-shell blender for adding liquid to dry materials contained in 2-page data sheet. Said to achieve perfect dispersion of liquids into dry materials in minutes & without clumping & agglomeration. Single blending operation introduces liquid into dry materials.

21 Spray Drying. Complete service in the field of spray drying is available from Bowen Engineering, Inc. Their well-illustrated bulletin covers laboratory, semi-works, pilot, & high tonnage spray dryers plus package production units. Complete details given on each type.

22 Centrifugal Pumps. From Ampco Metal, Inc., two bulletins, one on their bronze welding electrodes, the other on their centrifugal pumps. Both are well illustrated & replete with details of construction, usage, etc.

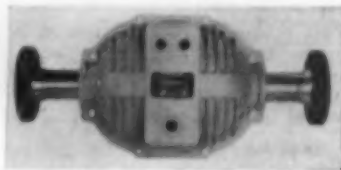
23 Industrial Filters. How these filters can lower production costs is theme of 10-page bulletin released by R. P. Adams Co., Inc. Cites case histories from filtering city water

(Continued on page 72)

DEVELOPMENTS OF THE MONTH (Continued)

66 Magnetic Flow Meter. This product of Foxboro Co., previously limited to minimum line size of 2 in., is now available for 1 in. flow lines. Smaller meter offers same unique advantages of larger unit. Accuracy $\pm 1\%$ of full scale throughout entire scale. No restriction of low, linear flow readings, performance unaffected by pressure, viscosity, density or changes in conductivity of flowing liquid. Unit consists of non-magnetic flow tube with an insulating liner containing flush-mounted metallic electrodes & surrounded by an a.c. electromagnet. When a conductive liquid passes through the tube, it sets up an alternating voltage between the electrodes which varies linearly

in proportion to the rate of flow. Lead wires from the electrodes transmit this voltage output to a Foxboro Dynalog Recorder which produces a chart record in appropriate units of flow. The 1 in. meter handles full scale flows of 10 gal./min. or greater. (Continued on page 73)



For Corrosion Resistance! Electrical Insulation!



BONATE BUILDS 'EM BIG AND BETTER!

This 20,000-gallon Bonate-built tank stores waste sulphuric acid prior to neutralization and eventual disposal. Fabricated for one of the industry's leading chemical producers, it surpassed the specs for strength and corrosion resistance. Tank, installation and maintenance costs were reduced!

We have the experience and ability to formulate and build the big ones! Would you like particulars? Inquiries invited.

CUT COSTS!

-with

Bonate

Glass Reinforced
POLYESTER,
EPOXY, PHENOLIC
LAMINATES

Carl N. Beetle
PLASTICS CORP.

Subsidiary of Crompton
and Knowles Loom Works

MOLDERS & FABRICATORS

processing, plating, storage & truck
tanks; ducts, pipe, stacks, parts, etc.

146 Globe Street
Fall River, Mass.
Tel: Osborne 7-9464

"EXTREMELY GOOD AGITATION and MIXING without ENTRAPPING AIR"

—with *Hermas Jet Mixer*—

One of this country's leading chemical manufacturers uses a Hermas Jet Mixer for blending concentrated paste and for making fine dispersions.

"We get extremely good agitation and mixing with your jet mixer," they state.

"And it does the job without entrapping air. We can use the full capacity of the mixing vessel due to the fact that there is no swirling action. There is no vortex and there is no foam, the reason for such superior performance."

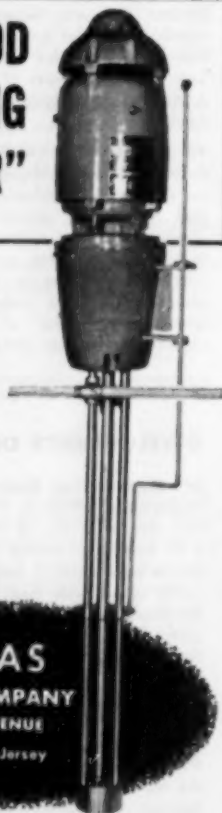
DISPERSION IS HIGHLY EFFICIENT

All material in the mixing container is drawn into the mixing chamber where it is immediately disintegrated homogeneously, compressed through the outlet jets, and discharged with high kinetic energy.

This continual recirculation of material, aided by the pumping action of the pitched turbine blades, is rapidly repeated until all the material is uniformly treated.

Send for Jet Mixer folder

HERMAS
MACHINE COMPANY
225 ROYAL AVENUE
Hawthorne, New Jersey



Technical Literature •

equipment-

(Continued from page 71)

to filtering recirculation water from cooling towers & spray ponds. New line of IWF filters featured. Shows sectional views in three colors, installation drawings, etc.

24 Mud Filter. Availability of a new bulletin on the Oliver-Campbell Mud Filter is announced by Dorr-Oliver Inc. Describes distinguishing characteristics, construction, sizes, operation & advantages of this widely applied can filter & auxiliary equipment required for operation.

25 Filter Aids. Celite line of filter aids from Johns-Manville. Illustrated bulletin describes details of nine types, technical assistance available.

26 Agitator Drive. Operation & maintenance of the Pfaudler Co. PW drive for agitators used in chemical processing covered in bulletin. New tips on installation & maintenance. Includes chart on recommended motor horsepower & shows suggested speeds plus other pertinent data.

27 Demineralization. A technical reprint from Graver Water Conditioning Co., "Status of Demineralizing for Treatment of Boiler Feedwater in Today's Power Plants," discusses in detail the advantages & disadvantages of this process. Of special interest to design, consulting & operating engineers.

28 Meter-Pump. Called Hills-McCanna-meter, this unit, a meter that pumps, is described in a new bulletin from Hills-McCanna Co. Meters small quantities precisely, pumps at high pressures, has a wide output flow range, has no frictional parts in liquid end. Cutaway view in color.

29 Stainless Steel Pipe. For those associated with the design or maintenance of processing equipment & piping an 8-page technical folder from the Tubular Products Div. of Babcock & Wilcox Co. Considers use of seamless & welded stainless steel pipe & stainless welding fittings in the process industry where corrosion & elevated temperatures are factors. Contains application data plus hints on bending, joining & welding.

✓ **CHECK** your Data Service requests on the handy postcard on page 65 to

▶ **GET** up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.

Developments of the Month (Continued)



67 TRANSITE PRESSURE PIPE INSTALLATION for overhead industrial water and process lines is covered in a new 48-page guide from John-Manville. Divided into 15 sections, text covers such subjects as: hanging and supporting the pipe, bracing for thrusts, the poured flange

coupling, and the Roto-split flange coupling. Diagrams of typical Transite systems for overhead lines are included. Additional feature is a listing of suppliers of fittings, accessories and couplings. In convenient 4½" x 8" size, guide's rounded corners make it easy to carry and use; ring binding to lay flat on desk or table; more than 50 illustrations.

(Continued on page 75)

30 Measuring Equipment. Eighty different devices are covered in a 40-page "testing-instruments reference book" just released by General Electric's Instrument Dept. Contains complete product information including applications, sources of additional information & pictures. Products range from simple thickness gages to the mass spectrometer leak detector. Measurement categories include color, leak detection, insulation & radiation monitoring.

31 Dryers. Titled "Engineered Drying," a bulletin from Surface Combustion Corp. Tells how continuous dryers replace batch operation in production of glue & gelatin, dairy products, chemicals, foods, pharmaceuticals, etc.

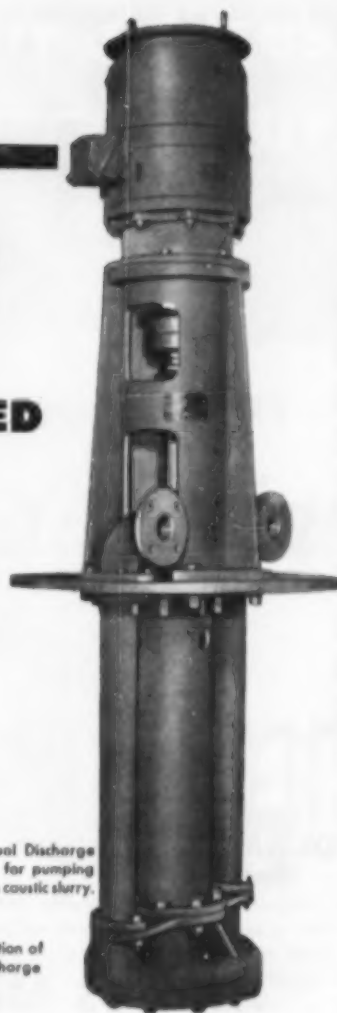
32 Flow & Level Sensing Devices. Automatic devices that indicate a lack of material supply or flow in a handling operation described in technical reference offered by Richardson Scale Co. Units give warning by bell, horn, light or other suitable means when lack of supply or flow is detected in chutes, conveyors, bins & the like.

33 Aluminum Flow Chart. Outlining the production of aluminum from mining of the ore through reduction to metal, an illustrated flow chart from Reynolds Metal Co. Wall chart printed in color is 15 by 21 in. Same chart available on heavy paperboard for teachers.

34 Temperature Regulator. A new bulletin from A. W. Cash Co. gives complete information on the Standard Staco Series V self operating temperature regulator. Recommended for steam, water, gases, & all fluids not corrosive to brass. Operates on a liquid filled thermostatic system, either direct or reverse acting.

(Continued on page 74)

VERTICAL PUMPS WITH NO SUBMERGED BEARINGS FOR PUMPING ABRASIVE CORROSIVE SLURRIES



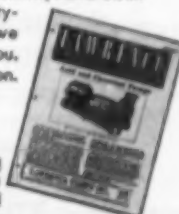
2" Dual Discharge Pump for pumping molten caustic slurry.

Cross section of Dual Discharge Pump.



This rugged type of service calls for advanced design: — extra heavy shaft, double-ported casing to equalize the side thrust of the impeller, and tough abrasion-corrosion resistant alloys. The dual discharge pump illustrated here incorporates these features and dispenses with bearings or packing below the cover plate where they would be in contact with the liquid.

Difficult pumping problems, particularly in the process industries, have been our specialty for ninety-one years. Perhaps we can be of help to you. Write us — no obligation.



LAWRENCE PUMPS INC.



Write for Bulletin 203-7 for complete summary of acid and chemical pump data.

371 MARKET STREET, LAWRENCE, MASS.



...here's one that lasts

There's an element of abrasion, too, in addition to the heat and some corrosion. It's a 3-way problem which our metallurgists recognize and understand. Duraloy Flights used in many kilns are taking care of these three requirements very satisfactorily.

While chromium and nickel in varying proportions are the principal alloying elements in most high alloy castings, sometimes operating conditions call for several alloying elements and knowledge of how to use them to bring out certain special characteristics.

In our thirty-five years of high alloy casting experience we have encountered and solved some very difficult corrosion — temperature — strength problems. Perhaps we can help you in connection with your high alloy casting requirements.

THE DURALOY COMPANY

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.

DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

CHICAGO OFFICE: 332 South Michigan Avenue

Technical Literature •

equipment-

(Continued from page 74)

35 Heat Exchangers. Air-cooled heat exchangers are the subject of a new Griscom-Russell Co. bulletin. Describes in detail design, construction, distinctive features & applications. Included are specifications, sketches of available arrangements, & descriptions of mechanical equipment & control apparatus for various service requirements.

36 Glass Pipe & Fittings. From Fischer & Porter Co. a new catalog on their line of glass pipe & fittings. Fabricated from Pyrex brand glass tubing, units are designed for laboratory or pilot plant use & special services. Sizes 1/4 to 1 in. internal diameter available from stock. Also described are new threaded metal couplings for metal-to-glass & glass-to-glass connections.

37 Attrition Mills. A double-disc attrition mill is one in which both discs revolve in opposite directions. Each disc is powered by a built-in motor or V-belt drive. Plates designed for the specific function are illustrated & described in a bulletin from Bauer Bros. Co. Mills are adaptable to grinding of materials including powdered metals, grains, wood flour, etc. Proper selection of mill plates & speed enables many types of special processing by attrition milling.

38 Vacuum Dehydrator. Developed by Chain Belt Co. an exclusive vacuum dehydrator. Because of its flexibility the continuous Chain Belt Vacuum Dehydrator can be adapted to drying a wide variety of products. Illustrated bulletin shows cut-away views, gives pertinent data.

39 Centrifugal Pumps. Double suction single-stage centrifugal pumps are described & illustrated in a new bulletin from C. H. Wheeler Mfg. Co. Recommended for general service wherever liquids of low viscosity are to be moved. Case is split on horizontal center line & rotating parts may be removed for maintenance without disturbing piping. Cross-section drawings & construction details for sizes to 10 in. discharge are included.

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► **GET** up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.

**Developments of the Month
(Continued)**



68 Temperature Controller. Fenwal, Inc. have designed as a plug-in unit a new thermistor-actuated temperature controller. Use is in assembling single- or multi-point temperature control systems. Consists of three elements: the plug-in control unit; a power supply on a separate chassis; a thermistor-sensing probe. Because unit is plug-in, a system for controlling temperatures at multiple points can be set up conveniently & economically simply by grouping required number of control units onto a single power chassis.

(Continued on page 77)

40 Control Valves. Known as "B" type control valves this line recently developed by C. B. Hunt & Son, Inc. is said to offer features never before available. Valve chambers of units are formed by aluminum spacers held in accurate metal to metal end abutment, a patented arrangement which simplifies internal construction. Available in single & double solenoid, also lever & single & double piloted designs.

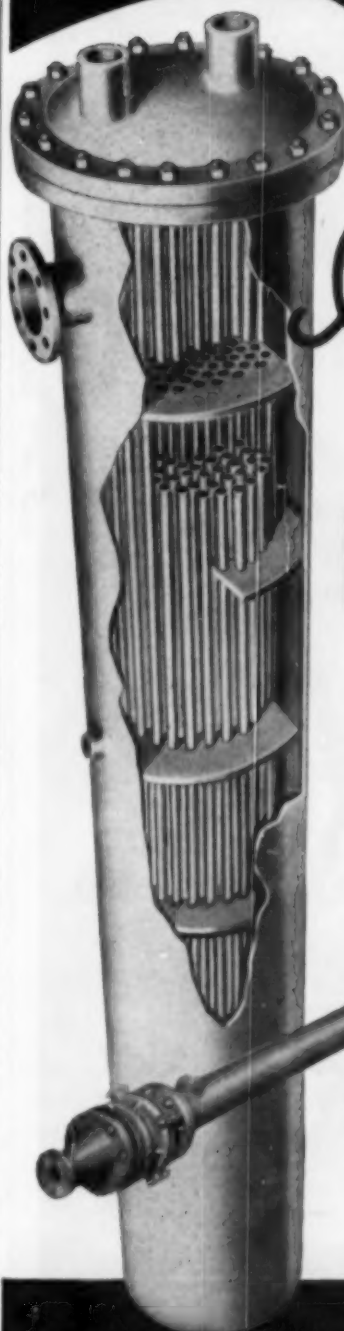
41 Valves. Said to be a new valve design & included in a bulletin from P-K Industries, Inc. are a line of valves specifically for use on tougher & more difficult problems in automatic & manual valve operation. An illustrated bulletin of interest to process & pressure system design engineers & users of automatic control & manual valve equipment is available.

42 Purchasing Guide. Engineers & technical purchasing specialists looking for the unusual & complex in alloy sheet metal fabrication will find this guide a helpful source of information. Published by S. Blickman, Inc. It anticipates problems, describes how special fabrication skills solved problems involving intricate shapes, close tolerances, special welding techniques.

43 Flow Meter. Transometer manufactured by Askania Regulator Co. is described in a bulletin. Gives applications for & features of unit. Unit comprises a positive displacement type flow meter & pneumatic signal transmitter. Diagram illustrates how device is used for flow, ratio & combustion control and other uses.

(Continued on page 76)

When your process runs a temperature



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Standard components are carried in stock for quick delivery of most IMPERVITE Tube and Shell exchangers from 7 to 650 tubes in 9 and 12 foot lengths. All normal tube and shell design features are available as standard. Custom designs are furnished on order.

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Featuring a rugged, heavy-duty, one-piece bundle, CROSS-BORE exchangers are furnished in standard, single and multi-pass models for heat transfer areas to 187 square feet. CROSS-BORE exchangers are especially easy to clean, and withstand operating pressures in the 150-200 psi range.

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IMPERVITE Cascade Coolers feature low-pressure-dropells and flush nozzles. As standard models they are furnished in 5 tube sizes, and three different models.

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Outstanding service is afforded by the Falls designed seal, which is virtually leak-proof. Standard IMPERVITE pump models are furnished up to 200 gpm, 100 ft. head, and specials are available in the range of 1000 gpm.

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Technical Literature •

equipment-

(Continued from page 75)

44 Hydrogen Sulphide Detection. An improved hand-operated detecting instrument for hydrogen sulphide announced by Mine Safety Appliances Co. Features dual scale to provide accurate readings in percentages by volume or in grains per hundred cubic feet. Detects concentrations as low as .0025 per cent & up to .04 per cent by volume.

45 Atmosphere Analyzer. A new bulletin from Harold Kruger Instruments describes an instrument for detecting & recording concentrations of pollutants in the atmosphere. Gives continuous record of ozone, nitrogen oxide, nitric oxide, & sulfur dioxide present in air.

46 Electrolytic Water Analyzer. An instrument for measurement of small quantities of water in gas streams is announced by Manufacturers Engineering & Equipment Corp. Simple & low priced, instrument permits of instantaneous & accurate measurement of water content down to less than one part per million.

47 Disintegrators. Added to Rietz Mfg. Co. line of size reduction equipment are model RI disintegrators. Wide range of applications in chemical process & related industries. Units are suitable for mounting in reaction vessels & for dispersion of liquids under pressure. Available in stainless or carbon steel as standard items.

48 Differential Refractometer. A new automatic recording mass collecting differential refractometer is announced by Phoenix Precision Instrument Co. Capable of plotting refractive index changes in any non-opaque liquid stream. Valuable for qualitative & quantitative analyses of materials such as alkaloids, steroids, antibiotics, rare earths.

49 Wire Rope. Recommendations for use in industrial services are the subject of a brochure from American Chain & Cable Co., Inc. Contains 24 pages of information-packed material. Covers more than 120 different types of wire ropes used in construction by bulldozers, scrapers, derricks, & many other units.

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► **GET** up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.

Developments of the Month (Continued)



69 NON-LUBRICATED LIFT-PLUG VALVES by Cameron Iron Works employ surfaces held to extreme tolerances to seal perfectly without lubricants. Friction is eliminated because plug is lifted from seat before rotating, never touching seat except when completely open or closed. Give satisfactory performance in oil well drilling & producing, refining & gas processing plants, pipe lines, & chemical plant & general services.

materials-

55 Compressed Gases & Gas Regulators. From the Matheson Co., Inc. a bulletin on their line of gases & gas regulators. Contents include information on adapters, controls, cylinders, various gases, gauges, valves & other items in the line.

56 Triallyl Citrate. Data sheet #521 on a new fermentation-derived compound from research by Chas. Pfizer & Co., Inc. Product is not in commercial supply but 4 oz. research samples are available without charge. Of special interest to polymer research groups.

57 Ion Exchange Catalysts. From Permutit Co. a new 12-page booklet entitled "Permutit Ion Exchange Catalysts." Describes advantages of using ion exchangers as catalysts for epoxidation of unsaturated oils & olefins, hydration of ethylene oxide, esterification of alcohols, & other uses.

58 Morpholine Derivatives. Technical bulletin on N-substituted morpholine derivatives released by Carbide & Carbon Chemicals Co. discusses uses & potential applications, physical & physiological properties, plus shipping data.

59 Epoxy Compounds. A series of three bulletins from Becco Chemical Div., Food Machinery & Chemical Corp., covers new long-chain epoxidized olefins, octylene oxide, dodecene oxide, & $C_{14}-C_{20}$ olefin oxide. Structure, typical properties & chemical reactivity of each compound are presented.

60 Propylene Diamine. A new technical bulletin on propylene diamine from Carbide & Carbon Chemical Co. presents information on uses, physical & physiological properties, specifications, & constant-boiling mixtures. Material is a strong organic base used in synthesis of chelating & sequestering agents for fuel oil & high octane gasoline.

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Illustrated above: View from enclosed end of "National" fourteen-section multiple-unit Single Apron Conveyor Dryer with three-zone control.

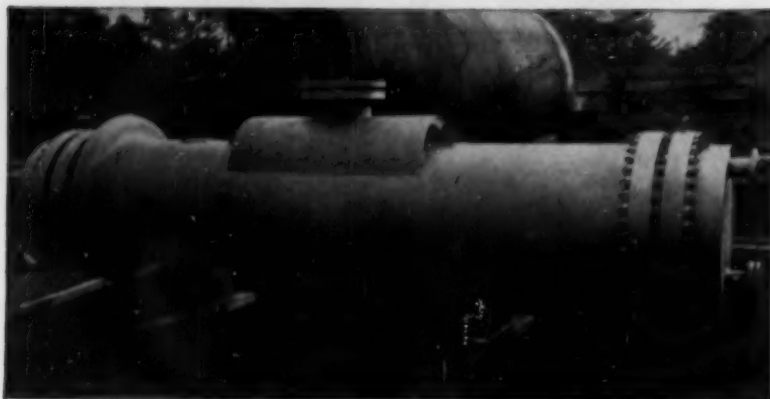
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Inconel and stainless heat exchanger built for Barrett Division, Allied Chemical & Dye Corporation. Shell Diameter: 30". Tube Length: 12' 0". Tubes: 1" O.D. x 14 ga. Tube Sheet Thickness: 2". Materials: Inconel shell, tubes, tube sheets. Stainless steel heads, Type 316L.

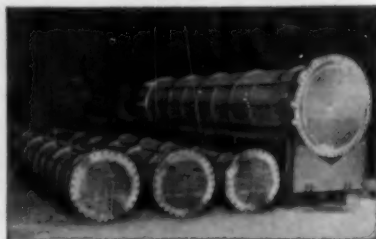
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Aluminum bronze for these five coolers saved the customer 25% on equipment costs, assured corrosion resistance. Each fixed tube sheet unit is 20" in diameter x 20' tube length. Each has 282 aluminum bronze tubes 3/4" O.D. x 12 ga. Centrifugally cast channels. Design pressure: 150 pounds per square inch on both shell and tube sides.



Stainless steel Type 304 is the material for these four tube bundles. The large one fits a 37" shell, has 1225 stainless tubes, 3/4" O.D. x 14' 0" long. Tube sheet: 2 3/8" thick. Baffles: 5/8" thick. The other three bundles are 22" in diameter; each contains 352 tubes 3/4" O.D. x 16 ga. x 12' 0" long. Tube sheets: 1 3/4" thick. Baffles: 1/4" thick. All stainless steel.



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CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

OVERSEAS NEWS

PHILLIPS EXPORTS LOW-PRESSURE POLYETHYLENE PROCESS TO ITALY

Low-pressure polyethylene, and other polyolefins, production battle now sees Phillips licensing its process in Italy.

Phillips Petroleum Co. has licensed Societe Solvay et Cie to use in Italy the Phillips-developed process for making rigid polyethylene by the low-pressure method. Solvay et Cie, while a Belgian company, has an operating office in Italy, and the agreement grants Solvay et Cie exclusive use of the Phillips patents and technical knowledge for the plastic in Italy.

Phillips itself is constructing a 110,000,000 pound per year plant to produce the low-pressure polyethylene at its Adams Terminal site on the Houston Ship Channel.

Under license from Phillips Petroleum, three French chemical companies will join forces to build a plant for the production of a family of plastics using Phillip's low-pressure polyethylene process. The French companies are Societe des Usines Chimiques Rhone-Poulenc, Etablissements Kuhlman and Compagnie Francaise de Raffinage. The plant will be located near Le Havre. □

The first Butyl synthetic rubber plant to be built overseas has been licensed to Societe du Caoutchouc Butyl, a corporation formed by ten French companies, by Esso Research and Engineering. Capacity will be 20,000 tons per year, on-stream date is expected in 1958, location is Port Jerome near Le Havre. □

A low-pressure polyethylene plant will be built in Beek, Netherlands, by Staatsmijnen who have bought the license for the Ziegler process for the entire Benelux. □

The first American company to put a factory in Munich, Germany, will be Beckman Instruments, Inc., when its new \$300,000 building is completed in late October. □

A multi-million-dollar contract for the modernization and expansion of Esso Standard Oil, S.A., Belot Refinery in Havana, Cuba, has been awarded to Arthur G. McKee and Co. Refinery capacity will be increased from 8,500 to 35,000 bbls./day. □



This 21,700 bbl./day refinery of the Commonwealth Refining Co. went on stream recently at Ponce, Puerto Rico. Almost immediately the Lummus Co., designer, engineer and constructor of the plant, was given a contract to more than double capacity. This new expansion will be completed early in 1957, will bring capacity to some 55,000 bbl./day.

Japan's first major petrochemical project will be a \$30 million facility for the production of chemical intermediate for the manufacture of synthetic textile fibers and other important chemical products, to be built by Mitsui Petrochemical Industries, Ltd. The project will be financed entirely by Japanese capital, but design and engineering of a large part of the facilities will be done by Scientific Design Co., New York. The major chemical move is aimed at the Southeast Asia market. □

A contract for the design and erection of a plant for the granulation of ammonium nitrate at the Grand-Couronne works of the French company Potasse & Engrais Chimiques has been given to the Engineering Division of the Societe Belge de L'Azote et des Produits Chimiques du Marly, a Belgian firm. The Belgian company will install its own process in the French plant. □

The new Soviet journal, *Atomic Energy*, published by the Academy of Sciences of the U.S.S.R., will be translated by Associated Technical Services, East Orange, N. J., and will be available at the rate of \$85 a year for the six issues. □

A 150-ton/day nitric acid plant will be designed and built for Potasse & Engrais Chimiques of Paris, France, by Chemical and Industrial International, Ltd., Nassau, Bahamas, a subsidiary of The Chemical and Industrial Corp., Cincinnati, O. C & I International, which has exclusive rights to license Chemical and Industrial's processes outside the United States and Canada, will build the plant at PEC's Grand Couronne nitrophosphate works. This is the first C&I designed high pressure nitric acid plant to be built in Europe where the atmospheric or low pressure method has been popular for many years. □

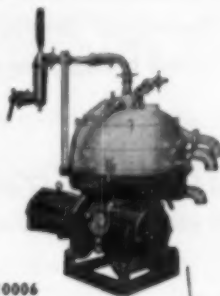
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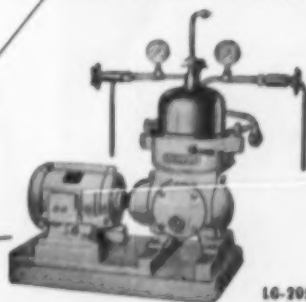


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"CONTAINMENT" PHILOSOPHY AT SAVANNAH RIVER

Du Pont sets up radiation control group to protect personnel and facilities, saves valuable time in long run.

Laboratories that work with radioactive materials are faced with the problem of protecting workers adequately from the hazards of radioactivity as well as preventing interruption of work in progress.

To this end, there are two basic philosophies:

1. Dilute, disperse and decontaminate.
2. Concentrate and contain.

In applications of the dilute and disperse method, the radioactive material is directly accessible to the worker; this practice is similar to normal chemical laboratory operations. The worker is protected by the design features of the building, the use of special clothing, and careful monitoring of his working area.

The second philosophy requires that the radioactive material be isolated from the worker at all times. This practice involves the use of gloved boxes, junior caves, and other specialized equipment.

Organization at Savannah River

After review of the experience of other laboratories, the Savannah River Laboratory adopted the containment philosophy. A radiation control group was formed to put this method into practice.

The radiation control group is divided into two subgroups: radiation facilities and radiation services.

The radiation facilities group, made up of both engineers and technicians, is responsible for the supply of all required special equipment, including gloved boxes, shielded facilities and associated manipulators, shielded containers and casks. To save time and money, special consideration has been given to standardization of equipment and interchangeability of parts.

The radiation services group contains engineers, technicians, and less highly trained inspectors. The major function of the group is to advise laboratory personnel on the hazards and methods of handling radioactive material and to procure, store, and disburse radioactive materials. Members of this group also assist in the training of new or inexperienced personnel, and are responsible for the monitoring of the area and personnel for presence of radioactivity.

The radiation control group as a whole operates in close liaison with the research staff. Each new operation is

discussed in advance and planned in detail. Every effort is made to provide adequate protective measures, including determination of what action should be taken in the event of an unusual incident, such as a spill of radioactive material, fire, equipment failure, or injury.

The laboratory has now been in operation slightly over two years, and results to date have been excellent. It would appear that the philosophy of containment offers many advantages in safeguarding personnel health, and in protecting an experimental facility from the hazards of handling radioactive material. The additional time required to plan and set up the operation frequently results in an overall decrease in time for completion of the project.

Condensed from a paper, "Containment Philosophy at the Savannah River Laboratory," by A. J. Hill, Jr., E. I. du Pont de Nemours and Company, presented at the Cleveland Nuclear Engineering and Science Congress.

When the second session of AEC's School of Nuclear Science and Engineering ended in June, the 62 students, including 47 from 23 foreign countries, who comprise the Third Session began advanced study at the School's facilities at Argonne National Laboratory. Their preliminary study at North Carolina State and Penn State completed, the group will embark on a ten-month session which includes unclassified courses in design, construction, and operation in nuclear research reactors; principles of power reactor design; handling of irradiated materials; and many other subjects concerned with peacetime application of atomic energy.

Among the foreign students, Ceylon, Denmark, Finland, Korea, Venezuela and Yugoslavia are represented for the first time. □

Thirty nuclear scientists and engineers, all of them prominent in their fields and several internationally famous for pioneer work in atomic energy, will spend from one to three months in San Diego this summer with the General Atomics Division of General Dynamics Corp. The summer-long conference with General Atomic's staff is considered by the company as an outstanding opportunity to plan the laboratory's immediate research and long-term goals. The unique experiment demonstrates General Atomic's belief that fundamental approaches are the most direct way toward significant technological accomplishments. Among the nuclear leaders present will be: Manson Benedict of MIT, R. Courant and R. D. Richtmyer of NYU, T. Welton of Oak Ridge, J. W. Kennedy of Washington Univ. in St. Louis, and D. Gurinsky, head of the metallurgy division at Brookhaven.

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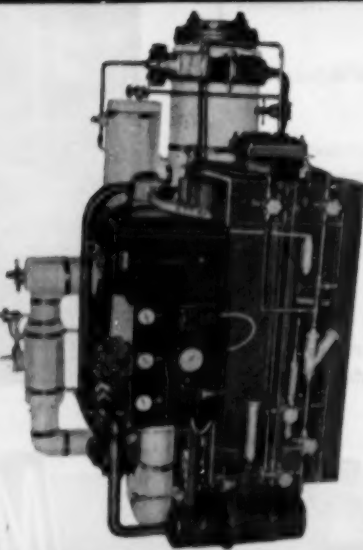
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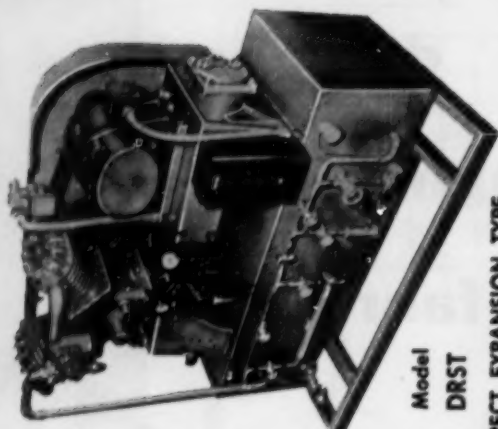


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PITTSBURGH

MEETING PROGRAM

SUNDAY, SEPTEMBER 9

INDUSTRY-UNIVERSITY RELATIONS IN THE PROCUREMENT OF TECHNICAL PERSONNEL—PANEL DISCUSSION, G. A. Webb, presiding.

Industry representatives are: Fred Denig, Koppers Co.; J. W. Reynolds, Chemical & Metallurgical Division, General Electric; C. B. Hill, Jr., Organic Chemical Dept., Du Pont.

University representatives are: E. W. Schoenborn, Dept. Chemical Engineering, North Carolina State; J. E. Hedrick, Cornell; C. E. Wangerman, Bureau of Placements, Carnegie Tech.

MONDAY, SEPTEMBER 10

SCIENTIFIC AIDS TO MANAGEMENT—CHEMICAL ENGINEERING OPERATIONS RESEARCH, G. D. Creelman, presiding.

Introduction to Operations Research, R. L. Ackoff, Case Institute, Cleveland, O.

Review of the evolution and present state of development and application of O. R. including the methods, tools, and problems it is best able to attack.

Methods and Tools of Operations Research, W. W. Cooper, Carnegie Tech, Pittsburgh, Pa.

A detailed description of the types of industrial applications of O.R.

Management and Scientists Form a Team—Some Problems in Cooperation, R. W. Wallen, Creelman, Associates, Cleveland, O.

The importance of the "team" concept in O.R. and some of the problems that are met in maintaining a cooperative team approach.

Putting Operations Research to Work in Industry, T. M. Ware, International Minerals and Chemical Corp., Chicago, Ill.

Ware, who has been responsible for the introduction of O.R. into his company, will discuss some of the practical problems involved in O.R. studies.

UNIT OPERATIONS IN NUCLEAR ENGINEERING, G. Sege, presiding. (Simultaneous with first Operations Research symposium.)

Heat Transfer to Water in Turbulent Flow in Internally Heated Annuli, R. P. Stein & W. Begell, Columbia U., New York.

Nearly 900 values of local heat transfer coefficients were correlated for water flowing through long annuli of varying widths, electrically heated at their inner surfaces. An equation giving the best correlation for evaluating physical properties at the usual film temperature was developed.

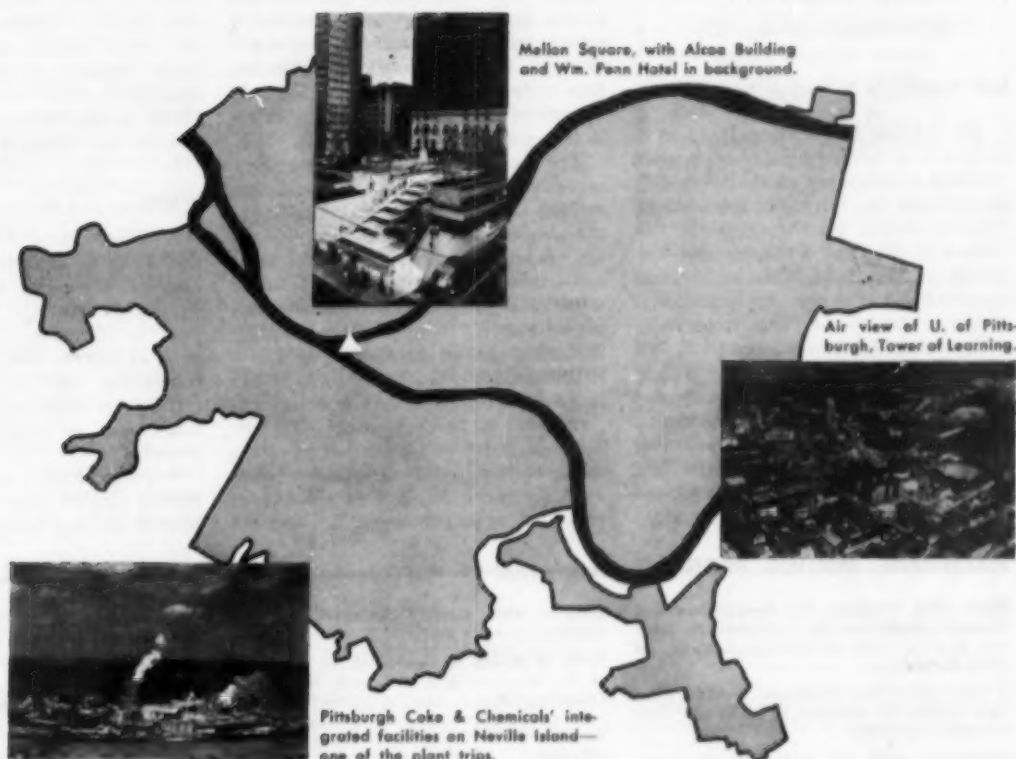
Void Fractions in Two-Phase, Steam-Water Flows, H. S. Isbin, N. C. Sher, and K. Eddy, Univ. of Minnesota, Minneapolis, Minn.

Void fractions and pressure drops were measured for steam-water mixtures, the void measurements compared with the reports of other investigators, and attention directed to the wide discrepancies existing in the current literature on two-phase flow.

Experimental Studies on Steam-Water Pressure Drops in an Annulus with Heat Transfer, C. R. McNutt & M. W. Carbon, General Electric, Richland, Wash.

In this study of two-phase flow, pressure drops are reported for forced circulation of steam-water mixtures through a uniformly heated annulus.

(Continued on page 84)



PITTSBURGH OFFERS BLUE-RIBBON PROGRAM

By J. S. Bardin & S. G. McGriff

The metamorphosis of Pittsburgh into a city of beauty, recreation, and culture makes it now one of the great monuments to American science and technology. Couple this with hospitable and convenient facilities for residence and entertainment, and you have a fitting site for the forthcoming fall meeting of A.I.Ch.E.—Sept. 9-12.

Kicking off on Sunday, a panel discussion on the recruiting of students for industry will explore ways in which industry-university relations can be improved for the benefit of the graduate making his decision regarding the first step of his technical career. Then, on Monday, the technical program begins.

That the technical sessions will comprise a program impressive in both scope of subjects and extent of presentation of new technical information is brought out in the following discussion of sessions—an adjunct to the detailed technical program included on the accompanying pages.

Scientific Aids to Management

Operations research, the scientific, or mathematical, approach to the solving

of management decision problems, is already an active field for many chemical engineers, who combine knowledge of

employment of engineers and scientists at higher levels of problem definition and solution. The morning session on O.R. will review these developments, the afternoon will be devoted to the reporting and discussion of actual case studies.

The statistical approach used in operations research is particularly useful to the engineer in planning for the future where quantitative account can be taken of the probabilities of the values of such critical factors as raw materials costs, market price of product, growth of market, and extent of competition. The range of application of these techniques is wide, and few chemical engineers will go home from Pittsburgh without being stimulated and better equipped to make use of these techniques, at least to some degree, in their own companies' operations.

Several of the large chemical and petroleum refining firms are represented by papers, and the meeting will provide an opportunity to learn what these leaders in the processing application of O.R. are doing, what their experience has been.

(Continued on page 84)

PLANT TRIPS

MONDAY, SEPTEMBER 10

| | |
|----------------------------|-----------|
| Mellon Institute | 9:30 A.M. |
| Pittsburgh Coke & Chemical | 9:30 A.M. |
| Shippingport Power Reactor | 1:30 P.M. |

TUESDAY, SEPTEMBER 11

| | |
|----------------------------|-----------|
| Pittsburgh Coke & Chemical | 9:30 A.M. |
| U. S. Bureau of Mines | 2:00 P.M. |
| U. S. Steel Corp. | 2:00 P.M. |

WEDNESDAY, SEPTEMBER 12

| | |
|-----------------------------|-----------|
| Aluminum Co. of America | 9:30 A.M. |
| Jones & Laughlin Steel | 9:30 A.M. |
| Gulf Research & Development | 1:00 P.M. |
| Climax Molybdenum Co. | 1:00 P.M. |

NOTE: Pre-registration for foreign nationals is required for the Shippingport and Pittsburgh Plate Glass trips.

processing with the specialized qualities of the O.R.-man. Now new methods are being developed which open fields for the

PITTSBURGH OFFERS . . .

(Continued from page 83)

Unit Operations in Nuclear Engineering

The Nuclear Engineering Division of A.I.Ch.E. is sponsoring this symposium which promises to have many interesting applications in the non-nuclear field. Primary reason for the choice of this subject at this time is the need for emphasis on the applicability of the unit operations approach to the solution of a large area of problems concerning economic nuclear power generation, fuel preparation and processing.

Nuclear needs, in both military and peaceful applications, have provided a fertile ground for the inspiration of major research into heat transfer and fluid flow, both reported on in selected papers in the two symposia on nuclear

engineering. The nuclear field has motivated unprecedented advancements in solvent extraction techniques, and much work has been stimulated on distillation, ion exchange, and other separations operations reported on (again as selected examples) in the symposia.

The chemical engineer attending these sessions will be schooled in the design and use of countercurrent ion exchange; the concatenated pulse column; means for transmitting pulses to pulse columns; and a number of other techniques useful in accomplishing improved separations or separation of materials exceedingly difficult to remove from each other.

While papers in these symposia are largely the result of work done in conjunction with atomic energy projects, they also represent important advances in the technology of chemical engineering. As such, they are in most cases translatable into non-nuclear applica-

tions. In addition, the rapid advancement seen in the commercial production of "rarer" metals—based on developments included in these symposia—is opening up a new industrial field which shows no signs of tapering off insofar as news of new projects is concerned.

Mixing

A strictly blue ribbon program on this subject of perennial interest to chemical engineers is assured for the Pittsburgh meeting. Papers will cover both liquid and dry solids systems, as well as the extension of information concerning the relationship between mixing and other co-existent unit operations, such as mass transfer, is concerned.

Scale-up of any system involving fluid motion may be aided greatly by fundamentals arising from studies to be re-

PITTSBURGH MEETING PROGRAM (Continued)

Nitric Acid Recovery by Evaporation and Fractional Distillation. D. S. Arnold, A. Whitman & F. J. Podlipiec, National Lead Co. of Ohio, Fernald, O.

Performance data developed from a plant scale system for recovery of nitric acid from extraction raffinates.

SCIENTIFIC AIDS TO MANAGEMENT—CHEMICAL ENGINEERING OPERATIONS RESEARCH. J. R. Bowman, presiding.

Production Planning—A case Study of Methoxide. H. A. Hashbarger & N. L. Sample, Monsanto, St. Louis, Mo.

A general discussion of the problem of control of production of 500 chemical products in over 1,000 grades at 13 locations, and the changes a study of the operation brought to the planning function.

Case Studies in Operations Research. A. F. Shorkey & J. Rio, Dow, Freeport, Texas.

Four applications of O.R. 1) A use of the Monte Carlo technique in the study of failures in cast iron batch reaction vessels. 2) Decision theory and the explicit consideration of probabilities in a problem of new equipment vs. modification in the face of new demand. 3) Reduction of finished product inventories. 4) Reduction of analyses on routine product shipments.

A Scheduling Problem in a Manufacturing Plant. B. O. Marshall, Jr., Mellon Institute, Pittsburgh, Pa.

An operational solution to the problem of minimization of substantial change-over costs. The solution method has wide application.

Operations Research in Process Engineering. A. R. Klingel, Jr. & C. L. Corvett, Standard Oil (Ohio), Cleveland, O.

Operations planning and forecasting, safety performance, maintenance, and a variety of process engineering problems studied from a viewpoint of O.R. methodology.

Optimizing a Catalytic Cracking Operation by the Method of Steepest Ascents and Linear Programming. R. W. Scharge, Esso Standard, Linden, N. J.

Use of a mathematical model, containing all the available knowledge of the situation, in studying the effect of changing operating conditions.

GENERAL PAPERS. A. Foust, presiding. (Simul-

taneous with second Operations Research symposium.)

Heats of Mixing of Liquids. H. W. Schnaible, H. C. Van Ness & J. M. Smith, Purdue U., Lafayette, Ind.

A two-constant equation, which correlates the data within experimental accuracy, is developed for heats of mixing for non-polar binary systems.

A full program of coffee hours, luncheons, tours and a fashion show have been planned

FOR THE LADIES

Sunday, September 9

2:30 PM—Welcome Tea.

8:00 PM—Get Acquainted Party.

Monday, September 10

9:30 AM—Coffee time.

12:00 Noon—Luncheon.

1:00 PM—Tour of Pittsburgh.

Tuesday, September 11

9:30 AM—Coffee time.

11:00 AM—Oakmont Country Club luncheon, tour of Pittsburgh Plate Glass Works.

7:00 PM—Banquet.

Wednesday, September 12

9:30 AM—Coffee time.

Tour—Alcoa Building, luncheon and fashion show.

Tickets for the Ladies' events may be obtained at the Registration Desk, Fort Duquesne Room, Wm. Penn Hotel. Ladies' Headquarters: Parlors E and F, 17th floor, Wm. Penn Hotel.

Scale-Up of Packed Pilot Gas Absorption Towers. M. Leva, Pittsburgh, Pa.

Experimental data for the system CO_2 -NaOH, using towers of 4, 6 and 8-inch diameters, leading to generalizations regarding the effect of column diameter, ratio of column diameter to packed height, and type of packing.

Nitrogen Oxides—A Challenge to Chemical Engineers. W. L. Faith, Air Pollution Foundation, Los Angeles, Cal.

Photochemically induced reaction between

organic compounds and NO_x in atmosphere is most logical explanation of smog, development of suitable control means is challenge to chemical engineer.

Ignition of Solid Propellants by Forced Convection. S. W. Churchill, R. W. Krugger & J. C. Brier, Univ. of Michigan, Ann Arbor.

Experimental data for the ignition of single grains of solid propellant in a stream of gas at high temperature. An equation representing the data is developed.

The Drying of Sand on a Hot Surface. R. W. Ludt, Michigan State, E. Lansing, Mich.

Drying rates, moisture distribution, temperature distribution and suction potential are correlated to determine the mechanism by which sand is dried on a hot surface in still air.

TUESDAY, SEPTEMBER 11

UNIT OPERATIONS IN NUCLEAR ENGINEERING. D. S. Arnold, presiding.

Pulse Transmission to a Pulse Column. C. Groot & V. R. Cooper, General Electric, Richland, Wash.

An expression is formulated for the minimum pressure developed by the momentum of the transmission line fluid. An example shows the relation between calculated and measured pressure.

The Concatenated Pulse Column. A. C. Jealous & Ephraim Lieberman, Union Carbide Nuclear, Oak Ridge, Tenn.

A concatenated pulse column consists of several short pulse-column sections interconnected by transfer tubes, pulsed in the same way as a standard pulse column. The significant features of a concatenated column are described.

Countercurrent Ion-Exchange. T. A. Arehart, J. C. Broese, C. W. Hancher & S. H. Jury, Union Carbide Nuclear, Oak Ridge.

Operational features and test results from a semi-continuous ion exchange contactor recently used to investigate the recovery of uranium from low-grade Western ores. A general discussion of the whole subject is given.

Roasting Techniques for the Removal of Fluorides from Ammonium Diuranate. E. R. Johnson, E. O. Rutenkroger, H. M. Beers & A. B. Kreuz-

ported on mass transfer effects in systems in which gas sorption and desorption is correlated with mechanical variables.

For the practical designer, reports on studies of geometry versus performance factors will include systems as large as 70,000 gallons capacity in which the use of strata of hot and cold liquids has permitted the employment of a thermometer as an excellent gauge of mixing progress.

Comparison between systems having a presence or absence of air-liquid interface will show results interesting to the designer. In another approach, boiling liquid has been studied. Bubbles cause mixing, and the Pittsburgh symposium will hear the first evaluation of the mixing effect so obtained.

One of the outstanding practical papers long awaited by many will be one comparing the performance of various commercial types of dry-solids mixing

equipment. Another paper will discuss the performance of a helical flight mixer. Significant, in the light of increasing use of statistical techniques by chemical engineers, will be a paper dealing with the use of this method in the determination of satisfactory mixing.

Explosions

Techniques used to prevent explosions is an unusual field about which many chemical engineers will be able to acquire useful information at Pittsburgh. Featured will be such subjects as the prevention of explosions in ducts, and techniques that could prevent destructive explosions of such dusts as starch, coal, or flour.

On this highly interesting subject, Gurney of Monsanto will show how dusts from a phenol-formaldehyde resin grinding operation resulted in a destruc-

FOR YOUR CALENDAR

A.I.Ch.E. National Meeting

Pittsburgh, Pennsylvania

September 9-12, 1956

Hotel William Penn

Registration: Fort Duquesne Room, 17th floor.

First technical session: 9:30 A.M. Monday

Last technical session: 3:50 P.M. Wednesday

Banquet: 7:00 P.M. Tuesday

tive explosion, and what has been done to prevent a recurrence. Control, prevention and detection of the hazards of industrial explosions will be covered in the other papers.

Bonus: a specially staged coal mine explosion for the engineers to observe.

(Continued on page 86)

men, National Lead Co. of Ohio, Fernald, Ohio.

Fluoride contamination in ammonium diuranate filter cakes can be removed by volatilization during calcination at above 1,250° F. The presence of steam will increase removal efficiency.

Uranium Refinery Waste Clarification, G. M. Reinhart & D. W. Glass, National Lead Co. of Ohio, Fernald, O.

A comparison is made between the effectiveness of magnesia and hydrated lime as a neutralizing and precipitating agent.

EXPLOSIONS IN CHEMICAL ENGINEERING, G. H. Damon, presiding. (Simultaneous with symposium on Unit Operations in Nuclear Engineering.)

Recent Research in Dust Explosions, I. Hartmann, Bureau of Mines, Pittsburgh, Pa.

Four recent studies involving the effect of moisture and dust fineness, flame speeds in explosions propagating through ducts, venting of dust explosions, and control of incipient explosions, among many other factors.

Industrial Explosion Hazards Detection, H. Lewis, Du Pont, Penns Grove, N. J.

Purpose, scope, equipment and techniques applicable to an explosion hazards testing program in chemical manufacturing operations.

Mist and Spray Explosions, J. H. Burgoyne, Imperial College, London, England.

A study of flammable suspensions having drop diameters of 0.01 mm. or less, showing their behavior to be very close to that of a vapor form.

Flammability Limits for Mixtures of Aircraft Fuels, Oxygen and Inert Gases, P. B. Stewart & E. S. Starkman, Univ. of California, Berkeley, Calif.

Data from these experiments show wider flammability limits than hitherto reported, also shows that the presence of liquid fuel also widens the limits over that when the gas phase is present alone.

The Determination of the Flammable Properties of Combustible Gases and Vapors at Elevated Temperatures and Pressures, R. E. Kennedy, G. S. Scott, & M. G. Zabetakis, U. S. Bureau of Mines, Pittsburgh, Pa.

Since the effects of temperature and pressure on the flammability characteristics of a combustible cannot yet be determined from basic

principles, special apparatus has been designed to gather experimental data starting at 10,000 lbs./sq.in., and details of the tests are given here.

GENERAL PAPERS, N. Amundson, presiding.

Vapor-Liquid Equilibrium of Nitrogen-Argon-Oxygen Mixtures, R. E. Latimer, Linde Air Products Co., Tonawanda, N. Y.

The vapor-liquid equilibrium of the 3-gas low temperature system over the range of pressure from 0.2 to 20 atm. is described by the simple equation for regular solutions, by simple equations for vapor pressures, and for the ratio of fugacity coefficients. The graphs are based on published experimental data.

Axial Mixing of Binary Gas Mixtures Flowing in a Random Bed of Spheres, K. W. McHenry, Jr., & R. H. Wilhelm, Princeton Univ., Princeton, N. J.

This paper suggests that, based on a series of experiments, axial diffusivity may not, perhaps, be neglected in contacting devices such as adsorbers and catalytic reactors.

High Velocity Spray Dryer, E. W. Comings & C. L. Coldren, Univ. of Illinois, Urbana.

A spray dryer of unique design and a greatly enhanced drying rate which should protect thermally sensitive substances from the effects of high temperature.

Absorption and Stripping Factor Functions for Distillation Calculations by Manual and Digital Computer Methods, W. C. Edmister, Calif. Research Corp., Richmond, Calif.

New functions of A and S factors are presented for computing multi-component separations in fractionators, reboiled absorbers, refluxed strippers, and columns with side-streams.

Diffusion in Three Component Gas Mixtures (Parts 1 and 2), H. L. Toor, Carnegie Tech, Pittsburgh, Pa.

A generalized driving force which describes diffusion barrier, osmotic diffusion, and reverse diffusion, is introduced, and approximate equations developed which give the individual rates of diffusion directly.

WEDNESDAY, SEPTEMBER 12

DISTILLATION COMPUTATION METHODS, W. C. Edmister, presiding.

Automatic Computer Procedure for Calculating Plates Required for Non-Ideal Ternary Continuous Distillation, A. Rose, T. J. Williams and H. C. Carlson, Penn State, University Park, Pa.

The use of a moderate-size computer in carrying out the multiplicity of numerical calculations required for a complex ternary distillation design.

A Practical Computer Approach to Distillation Column Design Calculations, J. A. Burtler, Du Pont, Wilmington, Del.

A practical technique for programming and operating a card-programmed computer where in the engineer conducts part of the operation himself using standardized decks of cards and wired boards for carrying out the plate-to-plate calculations.

Fractionator Design with Automatic Computing Equipment, Part 1—Product Mesh Method, R. L. McIntire, Phillips Petroleum, Bartlesville, Okla.

How a card-programmed computer has been used to carry out plate-to-plate calculations for multi-component hydrocarbon systems. In this case, the resulting products from a given column and conditions are found.

Part 2—Feed Mesh Method, R. O. Shelton & R. L. McIntire, Phillips, Bartlesville.

In this case, the objective of the calculations is the column design to give desired products.

An Integrated System for the Automatic Solution of Distillation Problems, J. S. Bonner, Humble Oil, Baytown, Tex.

Distillation calculation work that has been carried out on a drum-programmed computer.

MIXING, J. H. Rushton, presiding. (Simultaneous with symposium on Distillation Computation Methods.)

Blending with Side Entering Mixers: Low Viscosity Fluids, J. Y. Oldshue, H. E. Hirschland, & A. T. Grettton, Mixing Equipment Co., Rochester, N. Y.

Experimental results of studies of the blending of miscible fluids, with the problem of stratification, and the effects of several mixing variables.

The Dynamics of Liquid Agitation in the Absence of an Air-Liquid Interface, D. S. Laity & E. E. Treybal, New York U., New York.

The dynamics of agitating single- and two- (Continued on page 87)

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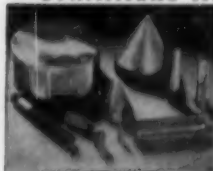
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PITTSBURGH MEETING

(Continued from page 85)

Distillation Computation Methods

Chemical engineers have long needed an easy way to solve complex distillation problems. Algebraic and graphical shortcuts have frequently been proposed, but they are of limited applicability, and when exact calculation results are required, the engineer is forced to make plate-to-plate calculations. This takes so much time that it is seldom done, and design data is often obtained by building and operating a pilot column, or the unit is oversized to compensate for uncertainties.

A rapid and rigorous machine calculation method for distillation would be a great aid to designers. In this symposium the latest work in this area is presented: work with analog and digital computers, wire and card programmed computers, stored program computers, and the currently considerable work on chemical engineering aspects of high speed stored program digital computers.

Applications of computer methods to the handling of such chemical engineering problems as the vapor-fluid K values, the enthalpies, and methods of meshing plate calculations to give column and terminal product results, will be presented.

General Papers

Always containing some of the highlights of any technical program, the general paper sessions have particular interest at the Pittsburgh meeting. A unique high velocity spray dryer that offers major potential for drying thermally sensitive substances through both a high drying rate and the controlled path of individual particles will be discussed. Why some liquid air plants have achieved separations that are impossible according to published data, is explained in a paper on vapor-liquid equilibrium of nitrogen-argon-oxygen mixtures in which the results of a careful thermodynamic study, over a period of years, of tall, large air rectifying columns, operating near minimum reflux ratios, have produced more accurate data. The role of nitrogen oxides in L. A. smog, and what the chemical engineer can do to solve this problem through controlling their emission, will be discussed. A paper on ignition of solid propellants by forced convection will unfold more of chemical engineering in the jet age.

These, and many more important papers in the symposia and the general sessions should add up to one of the best and most useful technical programs in many meetings.



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TECHNICAL PROGRAM

(Continued from page 85)

phase liquid mixtures in the absence of the interface are compared with those of similar systems with an inter-face.

Interfacial Area in Liquid-Liquid Dispersions Related to Fluid Motion in Mixing Vessels, W. A. Rodger, V. G. Trice, Jr., and J. H. Rushton, Argonne National Labs., Lemont, Ill., and Purdue Univ., Lafayette, Ind.

A study of the interfacial area produced in liquid-liquid systems in baffled cylindrical mixing vessels by the action of turbine type mixing impellers.

Gas Desorption, Fluid Mixing Motion, and System Size, H. A. Lindahl & J. H. Rushton, Purdue Univ., Lafayette, Ind.

Forced convection mass transfer coefficients for the desorption of carbon dioxide from water in three sizes of mixing vessels are related to the system size and to the fluid mechanics parameters that define the dynamic conditions of the turbulent fluid motion.

Effects of Bubbling and Stirring on Mass Transfer Coefficients in Liquids, D. L. Johnson, H. Salte, J. Polejes, & O. A. Hougen, Univ. of Wisconsin, Madison, Wisc.

Use of the hydrogenation of alphemethylstyrene in a stirred reactor with a suspended palladium-alumina catalyst to establish the effects of operating variables and mechanical construction on mass transfer coefficients in liquids in stirred reactors.

MIXING, H. F. Nolting, presiding.

Mass-Transfer in a Continuous-Flow Mixing Vessel, D. W. Humphrey & H. C. Van Ness, Purdue Univ., Lafayette, Ind.

Mass transfer coefficients determined for the dissolution of $\text{Na}_2\text{S}_2\text{O}_8 \cdot 5\text{H}_2\text{O}$ crystals in water under conditions of turbulent agitation in a mixing vessel. A method is developed for calculating the surface area of salt particles suspended in the mixing vessel under steady-flow conditions.

The Behavior of Suspended Particles in a Turbulent Fluid, S. K. Friedlander, Columbia U., New York.

Starting with a forced balance on the particles, and assuming the applicability of Stoke's law, expressions are derived for the mean square particle displacement. An illustrative calculation for the initial spreading of a jet of suspended particles is given.

Mixing Patterns in a Helical Flight Mixer, J. A. A. Greathead & W. H. C. Simmonds, Canadian Industries, Ltd., Montreal, Can., and Lobitos Oilfields, Ltd., Cheshire, Eng.

The experiment in this paper indicates the importance of the design of discharge, the degree of mixing expected from one mixer, and possible analogies with jiggling for this type of mixer.

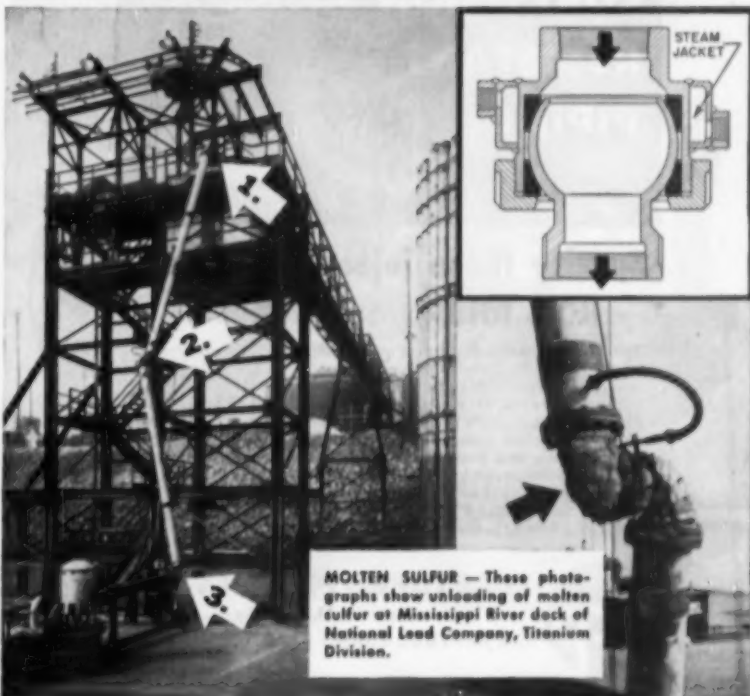
Performance of Dry-Solids Mixing Equipment, J. B. Gray, Du Pont, Wilmington, Del.

Quantitative mixing-performance data are presented for some types of equipment commonly used for mixing dry particulate solids. Large differences were found in the rates of mixing produced by various types of mixing equipment.

Statistical Determination of Satisfactory Mixing, S. S. Weidenbaum, Corning Glass Works, Corning, N. Y.

Several statistical tests of significance are given to determine whether a satisfactory mixture is produced under typical operating conditions.

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INSTITUTIONAL NEWS

ENGINEERS MIGRATE FROM FACULTIES TO INDUSTRY

DO ENGINEERS NEED HUMANITIES COURSES?

Meeting at Ames, Iowa, June 25-29, of American Society for Engineering Education heard and discussed two major reports of extreme importance to the future of the profession.

Features of the week-long meeting of ASEE at Ames, Iowa, were the reports of two vital studies conducted over the past few years by special committees of ASEE.

An intensive three-year study of the role of the humanities and social sciences in the education of the engineer, most comprehensive survey ever made by ASEE, concluded, in brief, that the humanities and social sciences are vital to the education of the engineer and must not be neglected.

The second study, A Survey on the Migration of Engineering Faculty Between Campus and Industry, indicated clearly that at present engineering schools are losing qualified teachers to industry at a time when enrollments are steadily increasing. The problem, in the view of the report, is serious in the extreme.

Humanities Vital

Science and technology tend to demand a rigorous specialization if the student is to master his subject and fulfill society's need. At the same time the engineer's position will almost certainly involve great social responsibility.

Made possible through a grant from the Carnegie Corporation of New York, the ASEE study was conducted by distinguished educators and industrial representatives headed by E. S. Burdell, president of the Cooper Union, G. A. Gullette, North Carolina State, and M. M. Boring, president of ASEE.

Result: the humanities and social sciences are, in a deeply serious sense, practical and useful.

The committee report suggests, "To meet his growing responsibilities and to realize his capacities as a human being, the engineer needs both professional competence and a broad understanding of himself and of the world in which he lives."

Result of the survey confirmed ASEE in its opinion that engineering students should spend at least one-fifth of their time studying the humanities and social sciences. Evidence in the survey "indi-



E. P. Stevenson, Arthur D. Little, tells dinner meeting at Ames that if our progress is to be maintained, we must develop more of the "new breed" of engineer who can work closely with scientists, and is capable of making creative contributions on the frontiers of science. Mathematics, the common language of scientist and engineer, is the tool on which the "scientist-engineer" must rely most heavily. Stevenson pointed to the engineer's growing concern with scientific areas where no fundamental engineering data are available and where he must develop his own.

cates that a majority of schools do not measure up to this standard; the national average is something less than 17%."

These studies in the humanities and social sciences must be as serious and basic as the science and engineering courses. Special "humanities for engineers" courses, such as "engineering history" or "engineering English," or superficial survey courses, or those which aim only to provide "a cultural veneer designed to make the engineer acceptable in polite society," are not what is required. The "finishing school" concept of the humanities has no place in modern education. Humanities courses the engineers take should deal with "subjects which, like science itself, are basic aspects of human activity in which depth of understanding provides the only sound foundation for the student's further growth."

The survey took special note of one vital problem concerning the humanities at engineering schools. This is the often open conflict between the arts and engineering faculties. "The attitudes of the engineering faculty communicate themselves to engineering students. At institutions where the faculty exhibited the greatest belligerence about their colleagues in the arts, we invariably found the greatest student complaint about the work in humanities and social science."

Loss Instead of Gain

The two-year survey of teacher migration, headed by A. R. Hellwarth, Detroit Edison, reported that in the last two years 750 engineering teachers left colleges for industry while 500 left indus-

(Continued on page 90)

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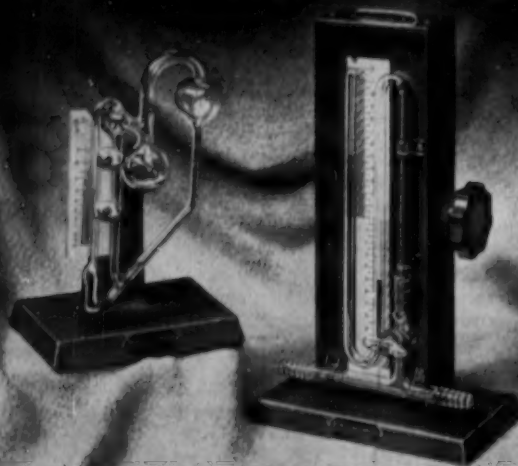


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INSTITUTIONAL NEWS

ENGINEER MIGRATION

(Continued from page 89)

try for the campus—a net loss to engineering faculties of some 3%. This may not appear too drastic, but it must be emphasized that engineering faculties actually needed 1,300 new teachers to handle the 1956-57 load, and the future looks little better. In essence, then, the teacher deficit is some 18%—a high figure. Further, these figures show only quantity. They do not show the fact that 118 of the men who went to industry were full and associate professors, one a department head, and the replacing of a departmental head is a large task.

Main reason: higher salaries in industry. However, greater opportunity and new experience were two other reasons noted, together with less work load and more chance to do research.

R. N. Dyer, Humble Oil, in discussing the report, agreed that salaries, not only beginning ones but the ultimate financial reward, are higher in industry, but also pointed to the lag of fringe benefits in the colleges. Dyer was also concerned about the college practice of basing raises on degrees held and seniority, suggesting a "cost of living" system as better all around.

Hellwarth reports that one dean summed up the situation with great simplicity: a) the offers graduates are now receiving from industry have coaxed away the bulk of the potential teachers; b) teaching staffs must be expanded in the next five years; c) practically all men must come from industry, since that is where they have gone.

Recommendations

The report came up with five recommendations to remedy the situation:

- 1) Compensation for graduate assistants.
- 2) Collective study of the problem (with industry, presumably) that will lead to collective action and to the elimination of competitive bidding.
- 3) Establishment of "chairs" and industrial subsidy (without strings) for key professors. (The ethical implications here must be explored carefully.)
- 4) Support of research on campus that would provide extra compensation for teachers.

5) Industrial consulting, summer jobs, one-day-a-week employment and other services that will provide financial incentive to keep good teachers on campus.

The survey committee is well aware, however, that a lot must be done beyond this to solve an admittedly difficult and dangerous situation.

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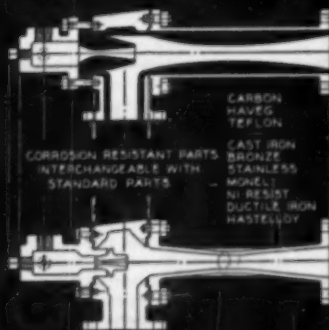
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FERMENTATION— MAJOR CHEMICAL TOOL

Analysis of fermentation as a chemical process tool of unique and positive value featured spring meeting of the Association of Consulting Chemists and Chemical Engineers in New York.

The primary factors in any fermentation process are: microorganism, substrate, and environment—and their complex inter-relations. Stressing these factors, A. J. Schmitz, head of Biological Process Development at Chas. Pfizer & Co. and main speaker at the meeting, went on to outline the problems and practices in modern fermentation installations.

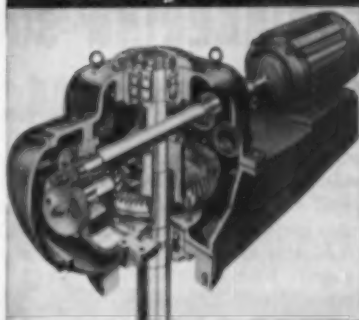
Today, a great deal of attention is being given to the proper design of fermentation equipment and necessary accessories. The essential tasks are: preparation and sterilization of the medium, provision of adequate aeration and agitation, and control of the key process variables. Each of these is handled far more reliably today due to the basic studies of the last decade.

In discussing the economics of fermentation process design, Schmitz analyzed the good and bad points of continuous operation. He pointed out that the three main drawbacks to continuous operation are said to be: contamination, organism degeneration, and modification of the effective productivity. The first two of these, however, are not necessarily as critical as opponents of continuous operation tend to insist.

In the open discussion period following Schmitz's talk, moderator D. R. Schwarz, vice president of Schwarz Laboratories, pointed to the growing applications of fermentation technology today, and Schmitz answered the perennial question of when should biosynthesis (fermentation) be used and when is direct chemical synthesis best? Schmitz suggested that fermentation is potentially useful when attempting to: (1) synthesize compounds with very large complex, or unusual structure, (2) prepare substances with a large number of asymmetric carbon atoms, (3) bring about slight structural changes in very complex molecules.—E. L. Gaden, Jr.

A dramatic new program designed to stimulate interest in science on the part of high school students will begin this Fall when eight high school science teachers will begin a nation-wide tour under the auspices of the Oak Ridge Institute of Nuclear Studies for the purpose of aiding high school science teachers throughout the nation. □

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ENGINEERING SOCIETIES CENTER IN NEW YORK CITY

The report of the Special Task Committee to study and make recommendations concerning the location of the proposed Engineering Societies Center has been issued. The Committee, composed of three members of each of the four Founding Societies and of A.I.Ch.E. and chairmanned by Barnett F. Dodge, Past-President of A.I.Ch.E. (other A.I.Ch.E. members were R. P. Kite and T. N. Chilton), makes five recommendations as follows:

1) The Engineering Societies Center be located in New York City.

2) The present 39th-40th Street site of the Engineering Building be continued in use as the site of the Center.

3) The United Engineering Trustees, Inc., expand by the addition of A.I.Ch.E.

4) U.E.T. be authorized to raise money, accept the fund raising offer of the Kelly Committee, take all necessary

action for the reconstruction of the present building and/or the construction of a new building or buildings, pay all costs out of capital fund assets, and operate and maintain the new Center.

5) The potential growth of the five societies be considered in building plans, and effort made to find facilities in the Center for all of the engineering profession.

To come up with these recommendations, the Task Committee studied all previous reports, employed a professional management consulting firm, McKinsey & Co., to assist in the study, interviewed the secretariats of all five societies, interviewed informed engineers throughout the country, discussed the matter with other engineering societies, and met with the various proponents of special plans from various cities.

Cities examined were New York, Philadelphia, Pittsburgh, Chicago, Washington, Shreveport, St. Louis and Kansas City. All but the first four were eliminated early, and the four remaining studied carefully.

Reporting on what the attributes of an Engineering Center should be, the Committee found, in essence, that it should: provide space and a prestige location for the entire staff of the five major societies; provide headquarters and meeting facilities for U.E.T., EJC, Engineer's Council for Professional Development, Engineering Manpower Commission, and the Boards of Joint Awards; space for other engineering societies if possible; and space for the Engineering Societies Library. Also called for was an allowance for growth and change in the engineering profession itself over the years.

INTERVIEW WITH THE CHAIRMAN



A special C.E.P. interview with Barnett F. Dodge, chairman of the Special Task Committee of the four Founder Societies and the A.I.Ch.E., and past-president, A.I.Ch.E., follows:

Q. What particular advantages does the plan outlined in the Report offer A.I.Ch.E.?

A. Besides the advantage of retaining the location of the Institute in New York City, there will be membership with the other four major societies in United Engineering Trustees (U.E.T.), which would mean sharing the ownership and occupancy of an Engineering Center site and building.

Q. Are there any disadvantages or problems as far as A.I.Ch.E. is concerned?

A. The raising of \$1½ million estimated to be necessary for purchase of a share in the ownership of U.E.T. equivalent to that owned by the other societies constitutes a major problem.

Q. Do you think this could be done and if so, how?

A. I do think it possible. Something like a half, or \$250 thousand, could probably be raised by an assessment of the members, amounting to the equivalent of about an extra year's dues. The other half might be borrowed as a long term loan, to be retired gradually out of income.

Q. Could the Kelly Committee's offer to raise funds for a new Engineering Center be interpreted as including the special appropriation by the A.I.Ch.E.?

A. I think it would be embarrassing to ask the Kelly Committee to put themselves in a position where they would be soliciting funds which would be used in part to equalize the equity of one society (A.I.Ch.E.) in the present real estate holdings of the other four. They might be willing to suggest, while asking for contributions for a new Engineering Center, that some donors might wish to earmark certain portions of their contributions to be used in the A.I.Ch.E. fund. The chemical industry might in this way subscribe an important amount of our needs, maybe \$250 thousand, or even the full amount.

Q. Is there any precedent in this matter of a society "buying its way in"?

A. Yes. A number of years ago the Civils bought their way into U.E.T.

Q. Could other societies, joining the Engineering Center later, "buy their way in"?

A. I don't recall that the Committee seriously considered this question. We felt that it was our task to act only for the five societies and whereas we did consider the possibility and desirability of including others in the Center later, we did not give any thought to the way in which this might be done. I think that most of us felt that only the five societies would be partners in UET and the others would come in only on a rental basis.

Q. Could the A.I.Ch.E. go into the Engineering Center on a similar "rental" basis?

A. It is the opinion of the A.I.Ch.E. representatives on this Committee (T. H. Chilton, Paul Kite and myself) that this would not be desirable, that entering on a basis of equality as a major engineering society would be the only role acceptable for the Institute.

Q. Are you satisfied that New York is the optimum city for the Engineering Center?

A. Yes. We considered all important possibilities, but found no decided advantages on the part of any city over and above New York City.

Q. Did you consider various locations from the standpoint of nearness to the center of society membership population?

A. We did, and concluded that being in a city most visited by members was the important factor. New York met this qualification, I believe, ideally.

Q. Was there any principal disadvantage to moving out of New York?

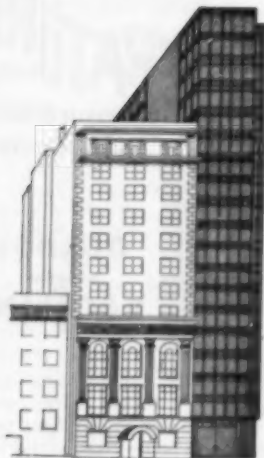
A. Yes. The uprooting of personnel would, in my opinion, be a serious problem not offset by any distinct advantages.

Q. Do you favor modernization of the present Engineering Building, plus some additional construction as described in the Report?

A. Yes, if an investigation by a competent architectural firm concludes that such is practical. We were not empowered to have such a study made. Our conclusions as to the site are therefore only preliminary. I believe that this site has definite advantages and should be given first consideration.

Q. What is the next step to be taken on the basis of the Report?

A. The recommendations embodied in the Report will be taken up for consideration for approval by the Councils of the five societies.



Artist's rough sketch showing how the proposed 18-story structure mentioned in the Task Committee Report might be constructed on the site adjoining the present Engineer's Club on West 40th Street, New York City. The new structure would connect with the present Engineering Building on West 39th Street.

Q. When do you expect the A.I.Ch.E. Council will take the matter under consideration?

A. I expect Council will give this consideration at its September meeting at the very latest, or sooner if a special meeting can be arranged.

Q. What specific action will the A.I.Ch.E. Council consider?

A. Council will decide the conditions under which they will accept the recommendation of the Committee, and the means for raising the necessary money.

Q. Do you care to express your hopes as to what Council will do?

A. Yes. I hope the Councils of all the societies will vote to go ahead with the Committee's proposals, and determine the means to do so.

Q. Anything else?

A. I would like to emphasize that we have before us a very important matter for consideration—one which may very well influence the development of the engineering profession over a period as long as the next 50 years. We should not be too precipitate in taking action but still we should act with boldness and vision, not just from the standpoint of A.I.Ch.E., but the engineering profession as a whole.

I should also like to take this opportunity to state that all the discussions of the Executive Committee and the full Committee were conducted in an atmosphere of friendliness and cooperation and a sincere desire to arrive at a result that would be for the best interests of the societies. There was never any serious disagreement nor any wrangling over petty matters. It was a great pleasure and a privilege to act as chairman for such a fine group. The harmonious spirit that prevailed throughout our discussion augurs well for the future of the professions.

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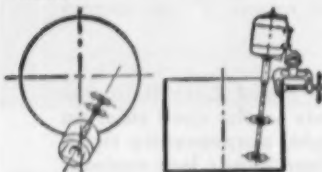
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FUTURE MEETINGS and Symposia of the Institute



Air view of Pittsburgh's "Golden Triangle."

MEETINGS

■ PITTSBURGH, PA.

Sept. 9-12, 1956. Wm. Penn Hotel.

See page 83 for story and complete meeting program.

■ ANNUAL—BOSTON, MASS.

Dec. 9-12, 1956. Hotel Statler.

TECHNICAL PROGRAM CHAIRMAN: W. C. Rousseau, Badger Mfg. Co., 230 Bent St., Cambridge 41, Mass.

SYMPOSIA

Filtration
CHAIRMAN: F. M. Tiller, U. of Houston, Cullen Boulevard, Houston 4, Tex.
The flow of liquids through compressible media with experimental and theoretical papers.

Low Temperature Techniques

CHAIRMAN: Clyde McKinley, Air Products Inc., Allentown, Pa.

Papers dealing with gas prepurification for low-temperature processing and the low temperature aspects of heat exchange, refrigeration, distillation and liquid-vapor equilibria, and the properties of materials.

The Sales Engineer in Chemical Engineering

CHAIRMEN: W. E. Hesler, Rodney Hunt Machine Co., 420 Lexington Ave., N. Y. C. 17, E. D. Kane, Cuno Eng. Corp., 5 Vine St., Meriden, Conn.

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Laboratory Facilities for Nuclear Engineering Education

CHAIRMAN: Joseph J. Martin, University of Mich., Dept. of Chem. & Metallurgical Eng., Ann Arbor, Mich.

Presentation of costs and uses of nuclear equipment in various educational curricula.

Chemical Engineering Aspects of the Paper Industry

CHAIRMAN: L. C. Jenness, U. of Maine, Orono, Me.

Afternoon at the Ichthyologists

General Session: "Obsolescence" of Chemical Engineers. Sunday P.M.: Round table discussion.

Deadline—August 9, 1956

■ WHITE SULPHUR SPRINGS, W. VA.

March 3-6, 1957. Greenbrier Hotel.

TECHNICAL PROGRAM CHAIRMAN: S. G. Friedman, E. I. duPont de Nemours & Co., Bengel Lab., Waynesboro, Va.

Computers in Chemical Company Control

CHAIRMAN: W. M. Carlson, du Pont, Engineering Service Div., Newark, Delaware.

The use of large-scale computers in handling payrolls, billing and ordering, sales forecasting, production control, etc.

Futures in the Chemical Industry

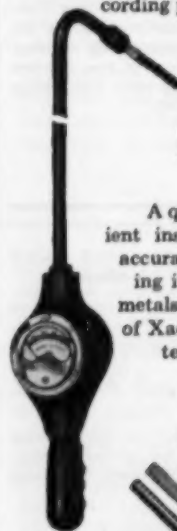
CHAIRMAN: To be assigned.

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FUTURE MEETINGS

(Continued)

MEETINGS

PHILADELPHIA, PA.

March 10 through 16, 1957.

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Expected to be confined to subjects directly applicable to the overall nuclear fuel cycle. Fuel cycles for power plants and possible plants utilizing high temperature heat are envisioned.

SEATTLE, WASH.

June 9-12, 1957. Olympic Hotel.

BALTIMORE, MD.

September 15-18, 1957. Lord Baltimore Hotel.

ANNUAL—CHICAGO, ILL.

December 8-11, 1957. Conrad Hilton Hotel.

TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind. Asst. Chairmen: A. L. Conn, Standard Oil Co., Box 431, Whiting, Ind.

Fluidization of Solids

CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.

Corrosion Resistant Alloy Materials of Construction

CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited.

Laboratory and Pilot Plant Techniques

CHAIRMAN: George W. Blum, Goodyear Tire & Rubber Co., Akron 16, Ohio.

Centrifugation

CHAIRMAN: James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kan.

The theory and quantitative aspects of centrifugation.

Drying

CHAIRMAN: Ralph E. Peck, Chem. Eng. Dept., Illinois Institute, 33rd Federal, Chicago 16, Ill.

Direct Operating Labor Costs

CHAIRMAN: John Happel, Chem. Eng. Dept., New York U., University Heights 53, N. Y.

Size Reduction

CHAIRMAN: Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.

Filtration & Centrifugation

CHAIRMAN: Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.

Chemical Engineering Process Dynamics as They Affect Automatic Control

CHAIRMAN: David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.

Ethylene Manufacture

CHAIRMAN: Hermann C. Schutt, 201 Devonshire St., Boston 10, Mass.

Dry Classification of Solids

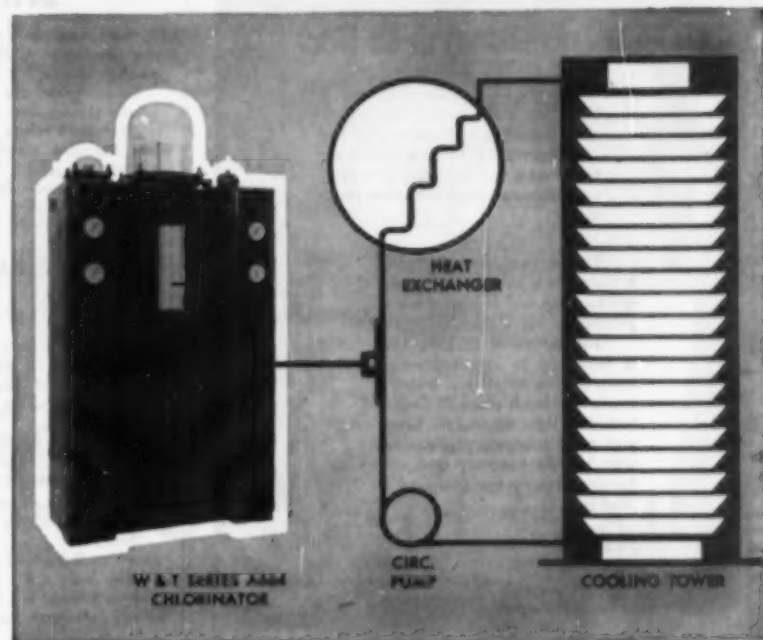
CHAIRMAN: D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.

Chemical Plant or Petroleum Process Plant Cost Estimates

CHAIRMAN: C. W. Nofsinger, the C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

(Continued on page 97)

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These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before August 15, 1956, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Grimm, Reginald H., Texas City, Tex.
Hamilton, Robert C., Anniston, Ala.
Hannah, Lee Theodore, Plainview, Tex.
Hansen, Waldemar H., Pitman, N. J.
Hanson, Gerald D., Baytown, Tex.
Hawley, E. R., Westfield, N. J.
Helpert, Raymond, Marshall, Tex.
Hess, Irwin H., Stamford, Conn.
Heyman, Norman S., Stamford, Conn.
Hill, William L., Hot Springs, Ark.
Hoffman, Stanley R., Chicago, Ill.
Holloway, Alan, Melbourne, Australia
Israel, Lawrence, Brooklyn, N. Y.
Johnson, John E., Jr., Aiken, S. C.
Jones, Herbert L., Jr., Pittsburgh, Pa.
Jorgensen, August H., Jr., Akron, Ohio
Keeling, Hugh E., Marshall, Ark.
Kitchens, Jesse Lee, Jr., Texas City, Tex.
Kramer, Robert T., South Charleston, W. Va.
Kyle, Martin L., Akron, Ohio
Lawley, James R., Jr., Baytown, Tex.
Labbauf, Habib, Baton Rouge, La.
Lohse, George E., Idaho Falls, Idaho
Maher, R., North Augusta, S. C.
Manis, Milton, Deer Park, Tex.
McDonough, Joseph A., Cincinnati, Ohio
Miller, Richard S., Schenectady, N. Y.
Moser, Donald J., New Albany, Ind.
Muschett, Ralph W., Jr., Waterbury, Conn.
Myers, William A., Fayetteville, Ark.
Nimmo, Douglas H., Cheboygan, Mich.
Noaker, Leslie J., Delta, Ohio
Olson, Donald Albert, Kansas City, Mo.
Ong, David K., Albuquerque, N. M.
Owens, James Durwood, Dickinson, Tex.
Papageorge, James P., Memphis, Tenn.
Platts, Dean B., McKeesport, Pa.
Porter, Miles G., Wilmington, Del.
Prichard, James J., Tonawanda, N. Y.
Rensen, Jules S., Pittsburgh, Pa.
Reyes, Rosalino R., Jr., Quezon City, Philippines
Robertson, Odes B., Port Arthur, Tex.
Rowland, J. C., Jr., Texas City, Tex.
Rush, John A., Walnut Ridge, Ark.
Saleeby, Roger N., Jr., Aiken, S. C.
Salemi, Robert M., Wilmington, Del.

Associate Member

Albrecht, George H., Manassas, L. I., N. Y.
Allyn, Charles L., Seattle, Wash.
Ashby, B. B., Baytown, Tex.
Bickham, George Francis, Auburn, Ala.
Blaser, Don E., Tulsa, Okla.
Brown, Joseph M., Newark, Del.
Byrd, John D., Bartlesville, Okla.
Campbell, Earnest D., Big Spring, Tex.
Cancelarich, John, Pine Bluff Arsenal, Ark.
Carter, James G., Vernon, Tex.
Coggan, L. B., Grinnell, Iowa
Corley, John P., Richland, Wash.
Drayer, Dennis E., Midland, Mich.
Fair, W. H., III, Corpus Christi, Tex.
Fallstrom, Leo, Stanington, Mich.
Fehrenbach, Paul, Menominee, Mich.
Flynn, John M., Midland, Mich.
Gaisert, Bruce A., Chicago, Ill.
Gould, Thomas R., Manville, N. J.

FUTURE MEETINGS

(Continued from page 95)

MEETINGS

SYMPOSIA

New Chemical Engineering Construction Techniques

CHAIRMAN: S. A. Guerrieri, The Lummus Co.,
385 Madison Ave., N. Y. 17.

Mineral Process Engineering and Mineral Economics

CHAIRMAN: L. A. Roe, International Minerals
& Chemical Corp., 20 North Wecker Drive,
Chicago 6, Ill.

LOCAL SECTION MEETINGS

NEW YORK

September 28, 1956, dinner meeting, Brass Rail,
43rd St. & 5th Ave. "Sonics and Ch. Eng."

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present
a paper before the A.I.Ch.E.," plus one copy of
"Guide to Authors" from Secretary, A.I.Ch.E.,
25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to
Technical Program Chairman for meeting se-
lected from above list.

3—Send another copy to Mr. E. R. Smoley,
The Lummus Co., 385 Madison Ave., New York
17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical En-
gineering Progress, 25 West 45th St., New York
36, N. Y. Paper will automatically be considered
for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected
symposium, send fourth copy to chairman of the
symposium.

6—Prepare five copies of manuscript. Send
one copy each to Symposium chairman, Tech-
nical Program chairman, or both copies to former
if no symposium is involved. Other three copies
should be sent to Editor, C.E.P. Presentation at
meeting offers no guarantee of acceptance for
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CANDIDATES

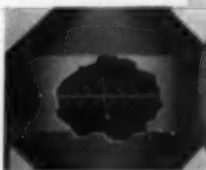
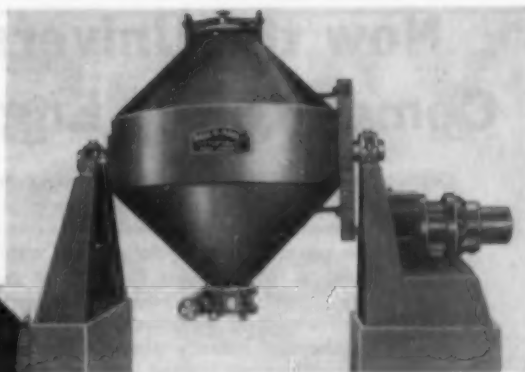
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Schindler, Harvey, Brooklyn, N. Y.
Schleusener, Dexter E., Painesville, Ohio
Schwartzberg, Henry G., Hoboken, N. J.
Seldomridge, R. L., Baytown, Tex.
Sengakis, Anthony, Rockville Centre, L. I., N. Y.
Shellenberger, Donald J., Pittsburgh, Pa.
Siwinski, George W., North Tonawanda, N. Y.
Slawinski, Frank E., Manistee, Mich.
Smith, W. J. S., Houston, Tex.
Spangler, Carl D., Jr., Shawnee, Kan.
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Stauffer, John D., Shelbyville, Ind.
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Ward, Henderson C., Atlanta, Ga.
West, Gerald R., St. Louis, Mo.
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Wilson, Thomas J., Little Rock, Ark.
Wingard, Lemuel B., Jr., Newark, Del.
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Fisher, Joseph H., Severna Park, Md.
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Chemical engineers can increase their popularity by kindness, their skill by doing, and their knowledge by study. There are numerous opportunities for extending themselves in the areas of human relations and applied science and engineering, but perhaps they find it more difficult to make equally substantial gains in study once they have left the environment of the university. This is particularly true in the chemical industry where in many instances its plants and facilities are located in isolated areas, thereby minimizing, if not making practically nonexistent, the chance for an organized or formal approach to study.

E. R. Cowherd

Physical Research Laboratory, The Dow Chemical Co., Midland, Mich.
Member, Professional Development Committee, A.I.Ch.E.

Much can be written on the relative merits of an organized study program contrasted to one that is self-motivated, but in general our experience has shown that where the first exists it is more productive and is preferred. A number of groups are finding this to be true and have made real efforts to introduce courses that will satisfy the interests of chemical engineers and others. This article describes the experience of the Midland, Michigan, local section with a formal study program.

As is the case elsewhere such as Charleston, West Virginia, and the Texas Gulf Region, Midland is located an inaccessible distance from a campus, in this instance 80 and 100 miles. Hence, for all practical purposes, it is not possible for people to continue working in the Midland area and at the same time attend classes on a campus. However, a campus is sufficiently close so that the possibility of bringing the classes to Midland was thought to be a real one.

Although there are many different subjects that could comprise a Professional Development Program, we were of the opinion that first and foremost, the chemical engineer should have the opportunity to continue his technical development. Thus, the local section's efforts have been primarily devoted to graduate courses in the field of chemical engineering.

We were fortunate in the fact that our interest in a graduate program in chemical engineering met with an equal interest on the part of the Department of Chemical and Metallurgical Engineering at the University of Michigan. Through the efforts of several people, particularly Professor R. R. White of the University of Michigan and R. M. Geiger of The Dow Chemical Company, the program has grown from what was initially an experiment to something real

that we believe will be with us for some time.

In September, 1952, the first course in a series of seven that have been presented to date was offered. It was titled "Advanced Heat Transfer and Fluid Flow." Data relative to the courses, including names of instructors, accompany this article.

It has been important for the University of Michigan to assure itself that the courses are comparable in every way to those given on the campus. To be sure of this, the courses in Midland have been given at the same time and supervised by the same instructor as on the campus. In every case, we have been concerned with three and four semester-hour credit courses which meet a respective number of hours a week. The university professor lectures one night a week in Midland, being able to do this by associating himself in each case with a recent advanced-degree graduate of the university who lives in Midland and

who has taken the course in question. The instructor gives one two-hour lecture a week and his Midland associate another. The assignments and examinations are identical in content and schedule to those given on the campus.

New Requirements for Credit

Originally it was possible to apply a maximum of six hours of credit obtained in this way to an advanced degree. With the success of the first course the university ruled that a man so enrolled could apply up to nineteen credit hours toward a master's degree. It was necessary, however, in order to obtain the degree, also to satisfy a residence requirement of one semester of courses on the campus in Ann Arbor. This requirement could also be met by the candidate's attending two summer sessions, each of eight weeks' duration, on the campus.

As a result of the interest and the satisfactory way the program in Midland had developed last year after five courses had been given, the university further reduced the residence requirement to just one eight-week summer session. At the same time The Dow Chemical Company and Dow Corning Corporation have made it possible for an employee participating in the program, when his work will permit and after he has completed sixteen credit hours of work, to take a leave of absence with pay to attend a summer session in Ann Arbor. The employee is expected to utilize his annual vacation for this purpose the year he takes such leave.

Degree Requirements

The Department of Chemical Engineering at the University of Michigan requires a minimum of thirty semester credit hours for the master's degree. The average student will be asked to

(Continued on page 104)

UNIVERSITY OF MICHIGAN COURSES GIVEN IN MIDLAND

| | When | Semester credit hours | For grad. credit | Audit | Total |
|---|--------------|-----------------------|------------------|-------|-------|
| Heat Transfer and Fluid Flow, S. W. Churchill, J. Eichhorn. | Fall, 1952 | 4 | 19 | 0 | 19 |
| Mass Transfer Operations, J. T. Bonchero, J. Eichhorn. | Spring, 1953 | 4 | 23 | 2 | 25 |
| Thermodynamics, C. M. Slipeovich, J. Eichhorn. | Fall, 1953 | 3 | 9 | 3 | 12 |
| Petroleum Refinery Engineering, B. R. Williams, R. B. Williams. | Spring, 1954 | 4 | 16 | 6 | 22 |
| Advanced Chemical Engineering Calculations (Math.), J. J. Martin, R. B. Williams. | Fall, 1954 | 3 | 16 | 2 | 18 |
| Mechanical Design of Process Equipment, E. H. Young, D. L. Engibous. | Spring, 1955 | 3 | 7 | 2 | 9 |
| Metals for Process Equipment, M. J. Sinnott, J. W. Fredrickson. | Fall, 1955 | 3 | 14 | 0 | 14 |
| | Total | 24 | 104 | 15 | 119 |



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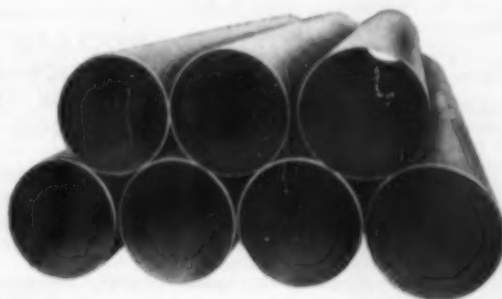
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News of the Field
FROM LOCAL SECTIONS

**SCIENTIFIC MANPOWER
PROBLEMS, HEAT TRANSFER,
FEATURE NEW JERSEY
MEETING**

Seventh Annual one-day meeting of the New Jersey Section attracts 279 engineers, highest turnout since 1954.

Better utilization of present scientific personnel is one major method of overcoming the serious shortage of top technological and scientific personnel in the country.

This was one of the major conclusions reached in a panel discussion on "The Engineering Manpower Situation" held at the New Jersey Section's one-day meeting in May. Panelists W. Cavanaugh, EJC; M. H. Trytten, National Research Council; D. L. Hiestand, Columbia Univ. also agreed on the necessity of improving pay and prestige of capable technical people and thereby help prevent them leaving science and engineering for the more lucrative managerial field where their contribution may not be as great in terms of the country's present needs.

Heat Transfer

Four papers were presented in the technical session—subject: heat transfer. D. Q. Kern, D. Q. Kern Associates, showed that the problems of operation and control which arise through the improper sizing and location of heat trans-

fer equipment fall into recurrent classifications and can be eliminated by more thorough analysis prior to installation.

Special purpose heat exchangers are finding increasing use in the chemical industry, according to R. E. Githens, Du Pont, who showed clearly how new ideas have changed the design of equipment such as steam jacketed kettles, heat exchanger heads, and expansion joints. Another new and growing facet of heat exchanger work is the application of scanning and logging systems to the presentation of temperature data obtained from the many temperature measuring elements, pointed out C. A. Ritter, Taylor Instrument Co.

James Y. Oldshue, Mixing Equipment Company, explained that heat transfer is an important aspect of mixing operations. It so often accompanies other processes that the type of surface chosen and the mixer design must satisfy the heat transfer requirements as well as other process considerations.

Writing and Thinking

R. Gunning, Robert Gunning Associates, and C. S. Whiting, McCann-Erickson, took up "communication" subjects. Gunning, speaking on how to improve the engineers' writing, pointed to methods of measuring readability of the writing as a means of getting to the final goal of clear, readable work. Whiting, an expert in techniques to improve individual and group thinking, showed that these methods not only improve the flow of ideas but improve communications as well.

At the evening dinner, Col. T. P. Gahan, Chemical Office, First Army, spoke on Power for Peace.

**NUCLEAR ENGINEERING,
PLASTICS AND RESINS
FEATURE LOCAL SECTION
MEETINGS**

Polyurethanes, leadership, defining basic and applied science also come in for study by local sections.

A heavy water moderated and cooled reactor, the proposed MIT research reactor will operate initially at a power level of 1,000 kw., according to T. J. Thompson, designer of the reactor, speaking to the March meeting of the Boston Section (M. K. White). Irradiation experiments in chemical engineering, chemistry, and other fields are already being planned, high neutron fluxes will be available in the graphite reflector, and neutron-free gamma radiation will be provided from spent fuel elements in a separate facility.

A broad, overall consideration of the

chemical engineering aspects of atomic energy was made by G. F. Jenkins, Carbide & Carbon, at the April meeting of the Charleston (W. Va.) Section (A. W. Byer). Jenkins emphasized the Government's desire to have business enter the atomic power generation field, pointing to recent Governmental review of all classified information for the purpose of making as much information as possible available to industry. In the more technical vein, Jenkins outlined the problems involved in reprocessing fuel elements and discussed some of the known recovery and purification methods, touched on new engineering techniques developed in connection with the atomic energy program, and went into non-power uses of radiation.

At present, storing radioactive waste material is an appreciable part of the cost of atomic work—some \$0.37 to \$2.00 per gallon. After pointing this out, A. J. Hoiberg, Lion Oil Co. division

(Continued on page 102)

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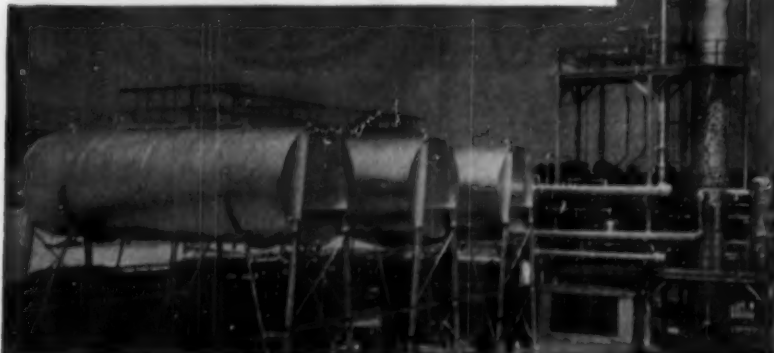
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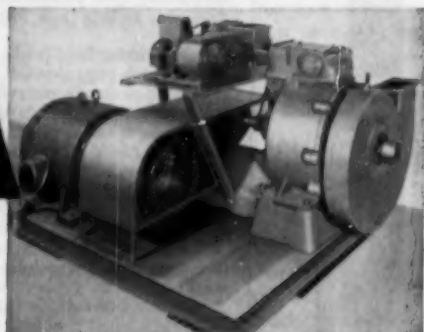
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News of the Field

FROM LOCAL SECTIONS

(Continued from page 100)

of Monsanto, described experiments in the use of catalytic asphalt membranes as a means of covering the walls of storage pits to the April meeting of the El Dorado Section (D. S. Thomas). Results indicated that membrane construction with a roof structure to prevent overflowing from precipitation can be carried out at a cost of around \$0.03 per gallon of solution stored.

Plastics and Resins

Over one hundred companies are said to be engaged at present in the rapidly growing field of polyurethanes. As E. M. Fettes, Thiokol Chemical Corp., showed the March meeting of the New York Section (A. B. Babcock, Jr.), the field offers diverse outlets including structural members, coatings, tires, flexible foam applications, insulation and acoustical material.

A brief description of one of the processes used for the manufacture of the methyl silanes, one of the basic raw materials for silicones, was given by J. S. Hurley, Jr., Silicone Dept. of General Electric, to the April meeting of the Atlanta Section (N. R. Maleady).

More often than not, H. Gershinowitz, Shell Development, stated to the March meeting of the Southern California Section (F. G. Sawyer), the distinction between basic and applied science lies only in the minds and intentions of the men doing the work. Efficiency of neutron capture by various atoms could be basic research at a university and applied research for a company studying nuclear reactors. This premise underlies much of the "fundamental" research being undertaken in hydrodynamics, elastic behavior of solids, colloid chemistry, and the reaction kinetics in flow systems.



Leadership Potential was the subject of a panel discussion at the April meeting of the Sabine Area Section (Neil S. Fussell). Panelists (l. to r.) H. M. Vaughan, Gulf; C. W. Cooper, Pure Oil; L. R. Strawn, Jefferson Chemical; and D. E. Campbell, Du Pont, analyzed the recognition and development of leadership potential, what qualities management considers most important in a supervisor, and how the chemical engineer compares to other employees as far as the potential for supervisory jobs is concerned.

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News of the Field

FROM LOCAL SECTIONS

NOW THE UNIVERSITY COMES TO THE ENGINEER

(Continued from page 98)

take perhaps thirty-two to thirty-three hours of work for the degree. There are three courses that are required of all candidates for the Master's in chemical engineering; all others are electives. These required courses, the first three given in Midland, are: 1) Heat Transfer and Fluid Flow; 2) Mass Transfer Operations; and 3) Thermodynamics.

All who enroll in the program for graduate credit must be accepted by the university as graduate students. They must have an undergraduate degree from an accredited curriculum and, where the major is other than chemical engineering, must satisfy certain undergraduate requirements in chemical engineering as determined by the graduate school. They must also have the usual undergraduate grade requirements or otherwise establish capacities for taking advanced work. To date, the people who have made application to the graduate school of the university have had,

in every case but one, a B.S. in chemical engineering. The exception holds a B.S. in chemistry. There have been only a few with an undergraduate major in chemistry taking the courses. Several, however, who have degrees in mechanical engineering, are interested in specific courses and not in the general program. This has also been true of those who have advanced degrees in chemical engineering.

Graduate Courses for Credit

Of the 119 man-courses that have been completed, 104 man-courses have been for graduate credit. This is contrary to an earlier experience with this system when a two-year course was offered a number of years ago. Usually persons who have audited the courses have not spent nearly as much time preparing for them as those taking them for credit. Much of the success of the courses is due to the high percentage of students taking them for credit. Although it is the intention of a number of people enrolled in the program to spend a summer in Ann Arbor satisfying the residence requirement, it is not for a number of others. However, the fact that this is a possible future action has encouraged people to take the courses for credit.

The major portion of those participat-

The Professional Development Committee of the Institute is anxious to see other local sections or groups of chemical engineers promote educational programs such as are described in this article. Chemical engineers are encouraged to take advantage of the opportunities which they offer. Where these study programs do not now exist, the Institute encourages groups to organize and put them into effect.

ing in the program are recent graduates. Only 25 to 30% of the classes have included persons who have been out of college ten years or longer. A number of the courses have required as many as fifteen hours a week of work in and outside the classroom, others something fewer than this. Although the courses are quite time consuming, the fact that the candidates have given up other activities and are willing to devote considerable time to this work is sufficient testimony to the importance that they have placed on this particular phase of their professional development. The program is operating in such a manner at present that if a person who has a B.S. in chemical engineering takes every course offered in Midland and attends one summer session in Ann Arbor, he can satisfy the requirements for a Master's in three and one-half to four years.

Other Programs

The graduate program in chemical engineering is only one of the three degree-granting graduate programs in the area. The Midland Section of the A.C.S. has sponsored for the past five years a similar program leading to the Master's degree in chemistry. The participating university in this program is Michigan State University which is located 80 miles from Midland in East Lansing, Michigan. A number of chemical engineers have taken and are taking these courses and have found them interesting and important in their work.

The University of Michigan is also giving its Master's program in Business Administration in Midland. The first two courses started in September, 1955. Two have been completed: Accounting and Business Law. Both are two-semester courses and the second semester of each is presently underway.

Equally important are the opportunities extended the chemical engineer to participate in Liberal Arts Courses which are offered in Midland by several universities and colleges, such as the University of Michigan, Michigan State University, and Central Michigan College. There are courses in history, art, literature, psychology, and the like. Some of these are given at the undergraduate and others at the graduate level. □

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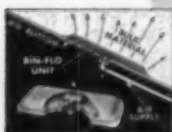
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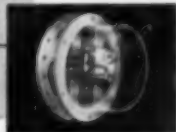


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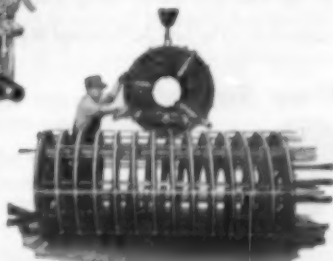
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Clifford C. Furnas, assistant secretary of defense for research and development, is



awarded the Honor Scroll of the Niagara Chapter of the American Institute of Chemists in recognition of his many years' service to academic and applied science. Presentation of the Scroll is made only

on rare occasions to those who have made exceptional contributions in the field.

Irving Leibson promoted to senior chemical engineer in the technical service division at Humble Oil & Refining's Baytown, Texas, refinery.

Anthony P. Massa joins the staff of F. H. McGraw & Co., N. Y., as process engineer in the engineering department.

The Pulp Chemicals Assoc., formed in 1955 as a trade association of manufacturers of chemical products produced by or derived from the sulphate wood pulping industry, re-elects Albert Scharwachter president, and elects Richard J. Spitz, vice president.

Commercial Solvents Corp., N. Y., announces the appointment of Hans M. P. Fischer as assistant to the vice president in charge of the company's petrochemicals division.

The board of The Chemstrand Corp. elects Edward A. O'Neal, Jr., president, to fill the vacancy created by the resignation of Henry H. Bidler of Decatur, Alabama, who is returning to American Viscose Corp. Mr. O'Neal is resigning as vice president and director of Monsanto Chemical Co., St. Louis.

Col. Theodore H. Marshall is promoted to the rank of Brigadier General, the first Chemical Corps reservist to be promoted to that rank. Long active in reserve affairs, since 1955 he has served as senior chemical officer in charge of mobilization detachment No. 10 in the N. Y. area.

In civilian life, General Marshall is associated with the Lederle Laboratories, Pearl River, N. Y., as chief engineer, overseas operations.



Marvin J. Udy, Niagara Falls, N. Y., associate and consultant of Stratmat, Ltd., a subsidiary of Strategic Materials Corp., received an honorary Doctor of Science Degree from Alfred University in recognition of his achievements in the field of electric furnace research.

Emil G. Klarmann, vice president and manager of technical services of Lehn & Fink, Inc., is recipient of an honorary Doctor of Science Degree from the Philadelphia College of Pharmacy for his contributions in the fields of germicides and antiseptics.

C. Rogers McCullough is elected president of the American Nuclear Society. He is assistant director, development department, of Monsanto, St. Louis, and chairman of the AEC's Advisory Committee on Reactor Safeguards.

Robert S. Ray, recently named vice president, now elected to the board of



directors and executive committee, Brea Chemicals, Los Angeles, Cal. Mr. Ray has been manager of manufacturing since 1953 when the firm's first plants were under construction. Prior to joining Brea he

was associated with Shell Chemical Corp. and Pan-American Refining.

Esso Research and Engineering Co., Linden, New Jersey, announces chemical engineering additions to its staff in various departments: Leonard W. Fish and Leon Bleich, petroleum development div.; Aloysius J. Zurl, economics division; and Earle A. Nirmaier, Jr., design division.

Horace W. Boynton and W. Mayo Smith, Jr., have been made assistant directors of research for Escambia Bay Chemical Corp.

F. R. Ward has joined the New York office of the Babcock and Wilcox Co. as a special assistant to the management of the atomic energy division. He had been technical assistant to the manager, large ship reactor project, in Westinghouse Electric's atomic power division.

Roger C. Clapp was the recipient of an A.I.Ch.E. award at the annual banquet of the student chapter at Northeastern U. Clapp was honored for being the top student for the past two years in academic standing in the department of chemical engineering.



William L. Rodich, general manager of General Electric's laminated and insulating products department, Coshoc-ton, Ohio, receives a "Certificate of Distinction" for professional achievement from Dr. Harry S. Rogers, president of the Polytechnic Institute of Brooklyn. Rodich was one of a group of 100 Polytechnic graduates honored at recent observance of the Institute's centennial year.

Warren L. McCabe, administrative dean of the Polytechnic Institute of Brooklyn, elected for a second term to the presidency of the Association of Engineering Colleges of N. Y. State.

Norman A. Copeland becomes assistant to the director of production at Du Pont's Wilmington film department. He was formerly in the firm's cellophane plant at Old Hickory, Tenn.

James S. Crowl appointed supervisor of process research by Acheson Col-loids, Port Huron, Mich.

The 1956-57 Texas Company Fel-lowship at N. Y. University College of Engineering received by **Jack J. Famul-aro**, Springfield, Mass., presently em-ployed at Monsanto Chemical Co.

William B. Davis named manager of the \$6 million plant for production of



synthetic fluid pe-troleum cracking catalysts being con-structed by Davi-son Chemical Co., Ltd., at Valley-field, near Mon-treal, Canada. With Davison since 1942, Davis has been staff assistant to **F. C. Nicholson**,

vice president, operations, at Curtis Bay Works.

B. K. Kallay becomes chief chemical engineer at the Sharples Division plant of Pennsalt Chemicals in Riverview, Mich. His former assignment was planning engineer.

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INSTITUTE EMPLOYEES HONORED



Lansing T. Dupree (left) and Miss Helen R. Glennon are shown receiving the congratulations of F. J. Van Antwerpen, secretary of the Institute and publisher of C.E.P. at a recent luncheon given at the Chemists' Club in New York by fellow employees. Marking their tenth anniversary with the organization, Mr. Dupree, advertising manager, and Miss Glennon, associate editor, were part of the original cadre gathered by Mr. Van Antwerpen (then editor) in 1946 to launch the magazine *Chemical Engineering Progress*. In respective citations, Miss Glennon was termed "the Institute's Bureau of Standards," and Mr. Dupree "an outstanding contributor to the Institute's improved economic picture."

R. C. Werner becomes associate director of research, in charge of the nuclear engineering division, Callery Chemical Co., in Pennsylvania.

John J. Reed is named product manager, isocyanates, by the National Aniline Div. of Allied Chemical & Dye Corp., N. Y.

V. L. Marquart has joined Fairchild Graphic Equipment, Inc., Jamaica, N. Y., as a research associate. He has been associated with the materials control division of the Curtis Publishing Co.

J. F. Mathis promoted to research specialist in the Humble Oil & Refining Company's Baytown, Texas, refinery.

William I. Thompson is named to the staff at General Dynamics Corp.'s General Atomic Division, San Diego, Cal., where he will serve as chief of process engineering in the division's research laboratory. His group will engage in work on the design and evaluation of reactor systems and components.

Necrology

J. Rich Holland, 66, Wiley & Co., Baltimore, Md.

A. R. Carr, Dean of Engineering at Wayne University.

George E. Wise, Jr., 33, E. I. du Pont de Nemours & Co., Yerkes Plant, Buffalo, N. Y.

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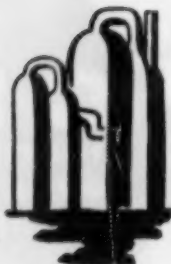
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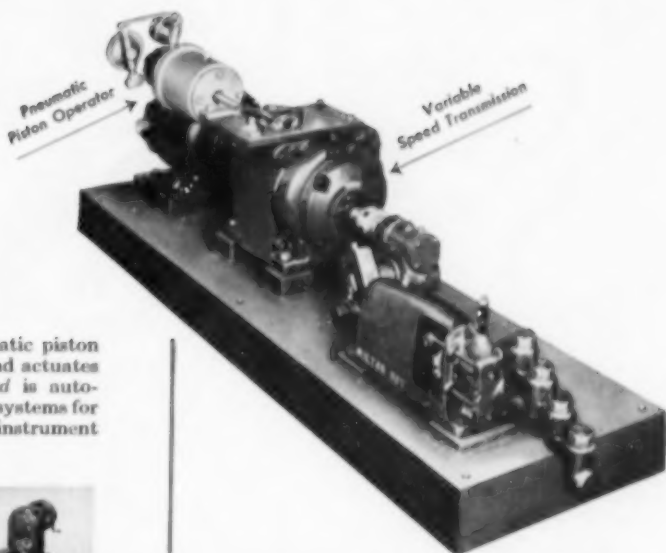
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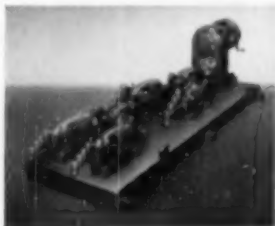
By Way of Emphasis: We repeat here two items well covered in the news columns of this month's issue . . . First is the report of the Nominating Committee, headed by B. F. Dodge, chairman . . . The committee suggested the following nominees: President—J. Henry Rushton; Vice-president—G. E. Holbrook & R. P. Dinsmore; Secretary—F. J. Van Antwerpen; Treasurer—G. G. Brown; Directors—George Armistead, Manson Benedict, Raymond Copson, Jack C. Dart, J. J. Healy, R. A. Kinckiner, Wheaton Kraft, H. L. Malakoff, Carl C. Monrad, Ralph A. Morgen, Sr., C. W. Nofsinger, & R. H. Wilhelm . . . In addition, nominations by petition were received for R. P. Dinsmore—Vice-president; E. J. Fox, Emerson J. Lyons & E. L. Piret, Directors . . . Personnel of the Nominating Committee was reported in this column in April . . . The second report, also from a committee headed by B. F. Dodge, concerns the **new engineering center**, & the recommendation is that it remain in New York & efforts be made to adapt and modernize the present structure on 39 Street plus additional frontage on 40 Street for the nation's engineers . . . Council at this writing will probably consider the report in a late August meeting or possibly the regularly scheduled Council meeting in September . . . The Housing Committee, under R. P. Kite, has been asked by Council to study the report & add its comments for Council's guidance. **More About New Orleans:** Ted von Wettberg headed part of the all-day meeting of the Institute Sections Activities Committee at New Orleans & presented the results of a poll on Local Sections: the majority of Local Sections have yearly dues of \$2, though 17 out of 52 have more than \$2 dues . . . most Local Sections do a pretty good job of collecting . . . 11 sections seem to have a rule that only A.I.Ch.E. members may belong to the local group, & 41 have a combined A.I.Ch.E. & non-A.I.Ch.E. membership . . . About 13,800 of the Institute's 15,600 members are in Local Section areas. Of these, 7,400 A.I.Ch.E. members pay

Local Section dues along with some 2,600 non-A.I.Ch.E. chemical engineers (paging the Membership Committee) . . . The purpose of Ted's survey was to find out how many Local Sections would favor a rebate from National of some part of the dues of members & the vote was 14 Local Sections in favor of the rebate and 35 opposed to it. **E.J.C.:** Walter E. Lobo has been appointed Chairman of the Engineers Joint Council Nominating Committee . . . This is Walter's first year as our representative to E.J.C. & he is also head of the E.J.C. Finance Committee. **Student Chapter Counselors:** University of Alabama, A. J. Still . . . University of Nebraska, J. H. Weber . . . Pennsylvania State University, E. T. Williams. **Program Committee News Letter:** The Program Committee is again reissuing monthly news letters to all members . . . Chairman "Cotton" Coulthurst & Vice-chairman Gene Smoley are combining their efforts to turn out an interesting fact and gossip sheet which is helping A.I.Ch.E. to continue the interesting & informative programs for which it is noted. **Sections Activities:** One of the important suggestions coming out of the meeting in New Orleans was that the Sections Activities Committee prepare a manual for Local Section officers . . . J. H. Rushton, chairman, has taken this under his wing & incorporated in it will be material written by members of the Sections Activities Committee, plus job descriptions of Local Section offices (already completed by Nevin Hiester). **Career Guidance:** Many of the Local Sections this past year did much, with the aid of Chuck Roen's Guidance Committee, to help high school students find out more about engineering as a career . . . There are a number of pamphlets available from this office on career guidance & Local Sections thinking of supplying speakers to high schools, young people's groups, Boy Scouts, etc., on engineering careers are invited to write for copies of the material aimed at interesting high school students in engineering. F.J.V.A.



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